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GLASS FIBER

By JOHN H. THOMAS[1]

THE subject of glass fiber has for a number of years held the interest of a few people who were attempting to study physical properties of materials by the use of fine fiber. In 1920, Griffith[2] presented a paper dealing with fine glass fiber, in which he mentioned the great increase in tensile strength that was obtained when fused quartz and glass were drawn into very fine fibers. However, it is only recently that glass fiber has been made on a commercial scale in which the strength of the fiber and other physical properties are important in controlling the quality of the product.

Owens-Illinois Glass Co. has developed a process by which they are now able to make commercially, fibers ranging in diameter from .010″ to .00005″ and as the diameter decreases very interesting strengths are developed.

Thread has been made from continuous glass fiber. This thread is composed of 60 individual filaments, each filament having a diameter of .0005″. Tests made on the individual filaments making up this thread show a tensile strength of approximately 250,000♯ per sq. in.

The length of these fibers is to all practical purposes infinite, individual fibers having been made as long as 5,000 miles without a break. The glass fiber is similar to silk or rayon in this respect, as they are the only two other commercial fibers that are not comparatively short.

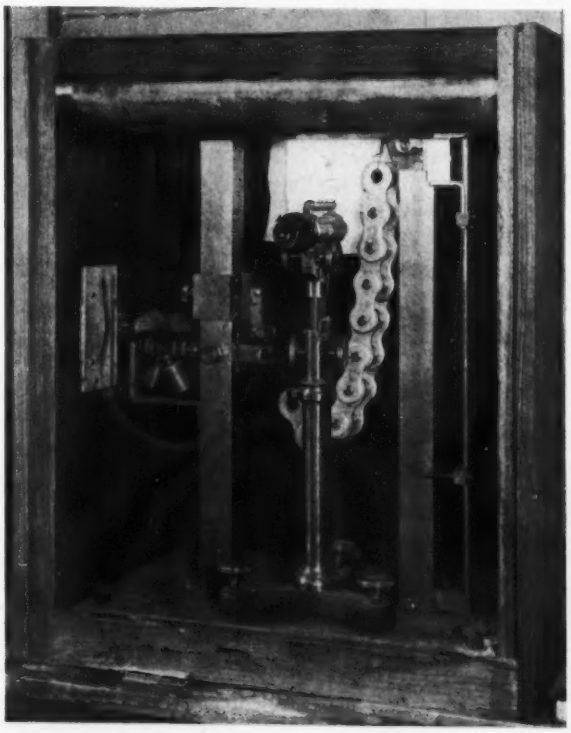
It is very interesting to note that the diameter of the 60 filament thread is .0067″, which breaks at 17,000♯ per sq. in. However, when the sum of the areas of the 60 filaments is taken as a basis, the breaking load is 247.000♯ per sq. in. or very close to the 250,000♯ per sq. in. of the individual filaments.

It is interesting to compare glass fibers with fused silica fibers. In the larger diameters, for example .002″, fused silica has a tensile strength of above 70,000♯ per sq. in. while glass may have a tensile strength of 28,000♯ per sq. in. In the smaller diameters, for example .00005″, fused silica has, in one test, reached a tensile strength of 3,163,000♯ per sq. in. while the highest glass strength so far obtained was 1,969,000♯ per sq. in.

A great number of glass fibers have been examined for strain, and in no case has strain in the fiber been detected, below a diameter of .001″, although no attempt is made to anneal the fiber. In view of this fact, it does not seem probable that the chilling rate of fine fiber affects the tensile strength. Supporting this viewpoint is the fact that fused silica, which has a much lower coefficient of expansion, has greater strength.

One very important feature of glass fibers is the great amount of surface per pound of glass. It is interesting to note that, while an ordinary quart bottle weighing 1½ lbs. has approximately 90 sq. in. of surface, a fiber of .00005″ diameter has 8,740,000 sq. in. of surface per pound. Surface effects which are negligible in large glass articles are of prime importance in these fine fibers. Calculations show that the length of these very fine fibers per pound of glass is very great, for instance, a fiber of .00005″ has 120,000,000 ft. per lb. or approximately 24,000 miles.

In order to determine the tensile strength of these very fine fibers, it was necessary to develop very sensitive equipment. Early tests were made by suspending a small bucket from one end of a fiber. This fiber was sealed to the bucket and to a bar with wax. The bucket was then loaded with very small weights until the fiber broke. The results obtained on this equipment were very erratic and a device was later developed on the chain-o-matic principle. Fig. 1 shows this equipment.



Device for testing tensile strength of glass fiber.

[1] Industrial Materials Research Laboratory, Owens-Illinois Glass Co. A discussion presented at the Fourth Conference on Glass Problems at Urbana, Illinois.

[2] A. A. Griffith. Proc. Roy. Soc. London.

Two steel posts, rigidly set on a solid steel base which is constructed so that it may be properly levelled, support the testing mechanism. One post is fitted with a slide carrying one end of the calibrated chain, a scale graduated in millimeters, and indices for reading the scale. The other end of the chain is fastened to a moving, counterbalanced arm, which is returned to the same point after each test, and to which one end of the filament, or strand, under test is attached by means of sealing wax. Above the movable arm is a stationary arm, movable to the extent that varying lengths of sample may be tested, but stationary during all tests. Posts are set in each of these arms to assure exact alignment of all samples. The sealing wax is softened by means of an electrical resistance coil, operated by a foot pedal and hinged so that it swings out of the operator's way during tests. The contact for the heating element is made by means of a micro-switch which makes contact when brought into position by the foot pedal.

The machine now used has three ranges, using three different calibrated chains. This, of course, can be expanded, at will, within reason. The chains are calibrated by use of an analytical balance, one end of the beam of which is attached to the movable, counterbalanced arm, the other being used for the weights at standard intervals. The sensitivity of this apparatus is very great. The smallest glass fibers produced—approximately 0.00005 in. in diameter—can be readily handled. The apparatus checks well with commercially obtainable tensile-strength apparatus.

In handling glass fibers as a textile material, fine strands of glass fiber are combined to give a thread of the desired size. The combining is accomplished by twisting the fine strands together. The fibers have been worked quite successfully on standard textile looms and the material has been knitted, braided and felted for different uses.

One very promising commercial application for glass textiles is as a filtering material. At present cotton cloth is used chiefly for this purpose. In acid solution cotton cloth has a very short life, while the acid resistance of the glass results in a much longer life. Filters of glass fiber are made in two forms, a mat form in which a felt of the glass fibers is impregnated with latex, and also as a woven cloth.

Another important application of glass textile material is its use as electrical insulation, being used as a winding on cables, and wire where high temperature insulating materials are desirable.

Although old in a limited sphere, glass fibers have recently become commercially available for a multitude of new uses. More are visualized in the future, and glass in fibrous form is rapidly assuming importance in many fields formerly closed to it because of a lack of commercial methods of producing the desired quality.

Acknowledgment is made to J. H. Plummer and F. O. Anderegg of this Laboratory, who have contributed greatly in developing both procedure and equipment for testing the tensile strength of fibers.

PENN STATE APPOINTS DR. WEYL

Pennsylvania State College has announced the appointment of Dr. Woldemar Weyl as associate professor of ceramics. Dr. Weyl has for several years been in charge of glass research at the Kaiser Wilhelm Institut fur Silikatforschung in Berlin, Germany. He is widely known for his work on the constitution of glass as well as for chemical investigations related to glass manufacture and certain refractory problems. At Penn State he will take charge of instruction on glass and whitewares and will direct experimental studies on problems concerning glass. Dr. Weyl takes the place of Dr. George J. Bair who recently resigned to join the staff of the Mellon Institute.

PHILIP I. HEUISLER IS DEAD

It is with profound regret that The GLASS INDUSTRY records the sudden death of Philip I. Heuisler, president and chairman of the executive committee of the Maryland Glass Corporation and president of the Emerson Drug Co. He suffered a stroke at Franconia, N. H., where he was vacationing, on Aug. 17 and died less than 12 hours later.

Mr. Heuisler was born in Baltimore in 1871. A graduate of Loyola College, he studied pharmacy at the University of Maryland and chemistry at Johns Hopkins University. About 46 years ago he became associated with the late Captain Isaac E. Emerson in the early days of the Emerson Drug Co., manufacturers of Bromo-Seltzer. In 1908 Captain Emerson organized the Maryland Glass Corporation and made Mr. Heuisler its president, an office which he continued to hold until his death. In 1931 he became president of the Emerson Drug Co., and when Joseph F. Hindes died last year he took on the duties of chairman of both companies.

Mr. Heuisler was also president and chairman of the executive committee of Bromo-Seltzer, Ltd., Toronto; chairman of the executive committee of the Emerson Hotel Co., and vice-president of the Citro Chemical Co., Maywood, N. J.

He was past president of the Glass Container Association of America, and was active in the affairs of this organization for many years. He was also active in the Proprietary Association, the Baltimore Drug Exchange and the American Pharmaceutical Association. He was a former president of the Rotary Club, a member of the Knights of Columbus, Maryland Pilgrims Association, Baltimore Country Club, Elkridge Club, Rolling Road Golf Club and Engineers Club.

In addition to his widow and seven daughters, Mr. Heuisler is survived by two sons; J. Stanley Heuisler, sales manager of the Emerson Drug Co. and Philip I. Heuisler, assistant treasurer of the Maryland Glass Corporation.

Joseph Early has recently been appointed chief engineer of the Phoenix Glass Co., Monaca, Pa. He was formerly associated with the Amsler-Morton Co.

SCHURECHT HEADS CERAMIC RESEARCH

Professor H. G. Schurecht has accepted the position as head of the newly established Department of Research of the New York State College of Ceramics. About 150 research projects for the Department of Research have already been suggested and listed and it is only a question as to which should be undertaken first. Glass men will be interested to know that a study of the raw materials available in New York state will be made with particular reference to silica deposits.

LIBERATION OF GASES FROM VITRIFIABLE MIXTURES CONTAINING BOTH SODIUM SULPHATE AND CARBONATE

By DR. H. JEBSEN-MARWEDEL

ABSTRACT—*We have observed the behavior of carbonates and sulphates entering into the composition of a glass in a state of reaction. It would appear that working conditions recommended by practice are justified, and that the decomposition of the sulphate follows the beginning of decomposition of the carbonate after a brief interval.*

THE presence of large bubbles in glass is a serious defect, considering the transparency of the material. In order to realize the conditions to which it is subjected, it is opportune to observe the rate of liberation of gases in course of the reactions which originate in the batch. The decomposition of the different raw materials has already been made the frequent objective of research. The general rate of speed of reactions taking place inside a charge with its constituents still in the solid state, is likewise known. As for conditions existing in the case of glass melting, they are, so to speak, unknown.

A notable survey of the work done on these several questions has been given us by Prof. W. E. S. Turner[1].

We proposed in the first place to study the liberation of gas of a normal mixture treated in a laboratory crucible under varied conditions. In no experiment did we try to attain a state of equilibrium; we strove rather to get continued liberation of gases arising from the carbonates and sulphates so as to make a new contribution to the study of the refining action of sulphates as compared to that of carbonates.

Experiments were made in gas-fired furnaces of which the temperatures were recorded. These furnaces had a surplus of heat such that at the moment of introduction of the crucibles, the temperature fall was scarcely perceptible. A check on combustion was obtained by intermittent readings, and we verified that the atmosphere of the furnace was almost neutral, the oxygen content being from 0.4 to 1.3 per cent.

The experiments were carried out with the following raw materials: Lippe sand, Kaiserode sulphate, Solvay soda ash and crushed limestone. The batch corresponded to that of a glass analyzing 72 per cent SiO_2, 14 per cent CaO, 14 per cent Na_2O. For each of the experiments new batch was used. We never pursued an experiment with a used salt. This was to eliminate certain sources of error on which it is useless to dwell.

1. Preliminary Experiments with a composition containing carbonate to the exclusion of sulphate.

For the experiments, we had at our disposal platinum crucibles of different shapes. Considering that we have often wondered if the heaping of the batch ought to be high or broad, we strove to bring into prominence the influence of the ratio between the exposed surface and the mass in the furnace. Besides, it was necessary to take into account that the partial pressures of atmosphere existing over the crucible, interfering with the dissipation of the gases being evolved from the composition, could sensibly influence the rate of the reactions.

To this end, an identical mixture was carried to 10000° C. in deep and in flat crucibles, and these two experiments were repeated in covered and open crucibles.

The results accord with the forecasts. Different values in igition loss resulted and the dispersion zones have higher limits in the open pot experiments. The greatest dispersion field belongs to the flat crucibles, the most reduced to the deep crucibles (Fig. 1).

The liberation of gases is perceptibly accelerated by a flatter heaping of the batch; on the other hand the presence of an atmosphere rich in gas arising from the dissociation retards decomposition. Unfortunately, too little is known of the conditions existing in heaped-up batch, at the moment that it melts, to be able to draw conclusions or even suggestions regarding the best shape or contour to give to the charge of batch in a furnace, in practice.

Despite all that, it remains of interest to have even a superficial idea of the influence of the spreading out of the charge, and of the atmosphere which surrounds it, on the rate of speed of decomposition.

Comparing the acquired results with other curves previously obtained, the influence of the spreading-out of the charge upon the emission of gas corresponds to that of a difference of 100° in the temperatures—50° for the higher layers—which is certainly not negligible.

In the course of the experiments, the necessity of choosing between the two forms of crucible made itself felt. We chose the deep crucible because it allows a better differentiation of the results obtained.

Influence of the weight of the charge—It was necessary to determine also the quantity of mixture best suited to the experiments. Being given that the fixation of this quantity has as its corollary the establishment of the proportion of surface to volume, it was to be anticipated that for a like crucible the emission of gas should decrease with the increase of the charge. This decrease is not caused by the partial pressures of gas in the interior of the charge only, but above all by the slower heating on account of the heavier mass being put into the crucible and needing to be brought to the chosen

The original of this article was in the French language, in the Belgian periodical Verre et Silicates Industriels, and was translated by Arch Schottland, Butler and Blairsville, Pa. There is some evidence that Dr. Jebsen-Marwedel originally wrote in German and that the French version is itself a translation, being a trifle ambiguous at times. We believe we have given the author's meaning correctly,—and that a German author, writing in French for a Belgian periodical and translated into English for an American one, may still be intelligible.

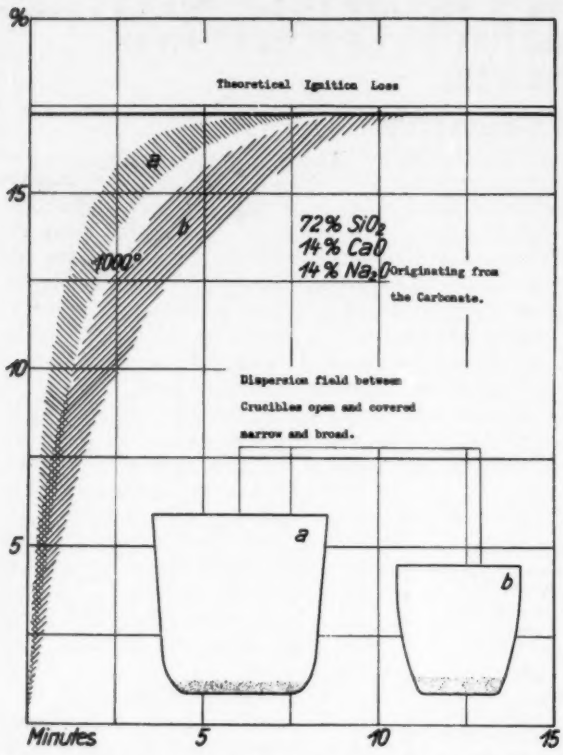


Fig. 1. Values of ignition losses of a batch with a basis of sodium carbonate, melted in crucibles, open and covered, wide and narrow.

temperature.

Quantities of batch weighing 5, 10, 15, 20, 25 grs. were put under identical conditions into a furnace at 1000° C. Fig. 2 shows smaller discrepancies between the zones of dispersion of the values obtained for experiments in open and covered crucibles, an indication of the slowing down of the tendency to dissociation with the increase of the mass, (low thermal conductivity). This influence is especially noted for the final values corresponding to ignition losses theoretically calculated. The crucible containing 20 grs. reaches this final value only after 13 minutes; that containing 5 grs. reaches it after nine minutes.

With the object of obtaining another representation of the slackening in the liberation of gas with increasing masses it suffices to graph the contents of the crucibles in terms of ignition losses and to connect by a line all the points reached at the end of the same time in minutes. The result is a sheaf of curves which will very clearly express the value of ignition losses for the duration of equal heats in terms of the increase of the content of the crucibles. The lower limit of the residuary field marked in black on Fig. 3 is representative of existing conditions after 10 minutes. We may note that the 5 gr. crucible has got ahead of the 25 gr. crucible by nearly a third of the total ignition loss.

After having shown the order of the magnitude of the influence of the content of the crucible, the following experiments, the most precise, were carried out with a quality of 5 grs.

2. Mixture containing both carbonate and sulphate.

We owe to G. Tamman and W. Olsen[2] a very important contribution on the phenomena which develop at the time of melting of compositions containing sulphate.

We set out to differentiate between the liberations of gases from compositions containing a mixture of alkaline salts like the industrial compositions generally employed.

The procedure followed the table below:

	SiO_2		$CaCO_3$		Na_2CO_3		Na_2SO_4	
	SiO_2	Sand	CaO	Lime-stone	Na_2O	Soda Ash	Na_2O	Sulphate
	%	g	%	g	%	g	%	g
A	72	72.36	14	25.23	14	24.15	..	....
B	72	72.36	14	25.23	12	20.75	2	4.64
C	72	72.36	14	25.23	7	12.10	7	16.25
D	72	72.36	14	25.23	..	....	14	32.51
E	72	72.36	14	25.23	..	....	14	32.44*

* In the sulphate figure under "E" there is included 5% (equal to 1.606 g.) charcoal.

The compositions subjected to experiments are the following:

A. Compositions with a base of sodium carbonate only.

B. Composition in which the alkali has been introduced to a slight degree only (1 part in 7) in the form of sulphate (sulphate as a refining agent).

C. Composition in which alkali has been introduced half in the form of sodium carbonate, half as sodium sulphate.

D. Composition with a base of sodium sulphate only.

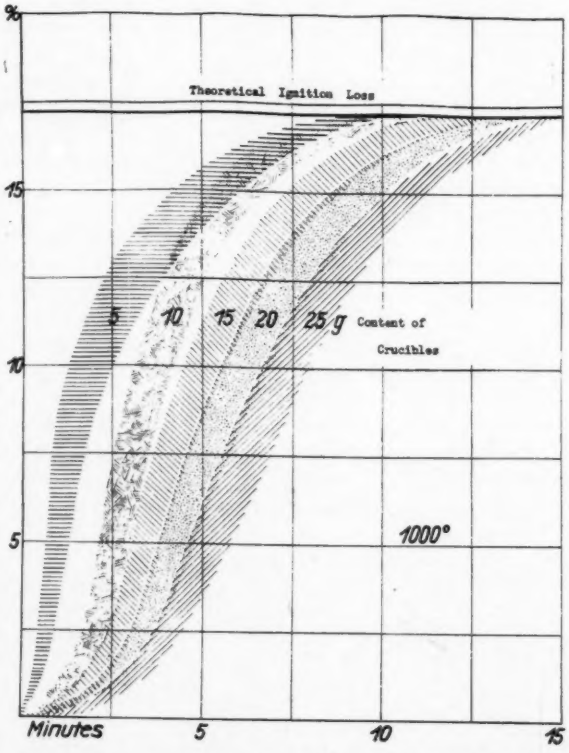


Fig. 2. Narrowing of the dispersion zone of ignition loss values with the increase in weight of the melt in open and covered crucibles.

E. Composition with a base of sodium sulphate with a small quality of charcoal.

Graduation of temperatures.

A. Research began with a composition containing only carbonate such as served in the preliminary experiments and we studied the way in which it behaves at different temperatures between 900° and 1300° C. For that we determined the ignition losses by weight, after certain intervals of time, and expressed this value in per cent. Fig. 4 indicates that the dissipation of gases is accelerated with the increase in temperature.

Being given the impossibility of avoiding a certain loss through expulsion due to the violence of the reactions, we found final ignition loss values higher than the values theoretically calculated. This value was corrected in terms of the weight of the residue and of the theoretical ignition loss and it is the corrected values which have been carried out in the diagram.

B. In this experiment 2 per cent of the 14 per cent of Na_2O was introduced in the form of sulphate, which corresponds to the use of this salt as a refining agent. We proceded as above.

Losses of ejecta are again verified with the dissipation of SO_3 and of CO_2: These two components remaining partially present, in different proportions of course—in the residue. It was therefore necessary to proceed analytically. If the ejecta losses had been constant or even if they had been a function of the duration of the heat or of the temperature, it would have been possible to neglect them but since despite all care they varied perceptibly, it was necessary to make corrections by calculation in the values found.

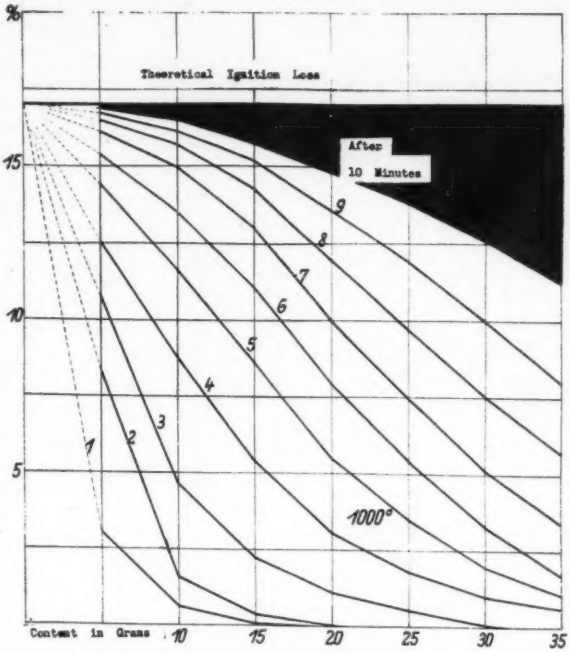
This procedure was as follows:

(a) Ascertained value of ignition loss		15.33
(b) Ascertained value of the residual SO_3		7.58
c equals a plus b	sum	22.91
(d) Theoretical gas content		22.60
(e) Loss from ejecta		.31
a-e Actual ignition loss		15.02
(a-e) plus b equals d		
This quantity (a-e) should be in its turn divided between SO_3 and CO_2 whence:		
f equals total theoretical quantity of SO_3		14.07
g SO_3 Residue		7.58
f-g equals volatile SO_3 contained in a-e		6.49
a-e equals total ignition loss		15.02
(a-e)-(f-g)		6.49
	Volatile CO_2	8.53

Unfortunately all the figures determined by experiment have had to be corrected by calculation, but these corrected values substantially fit into the path of the curves.

Fig. 5 indicates that dissipation of CO_2 takes place without modifications as in Fig. 4. It would seem that the dissipation of SO_3 reaches the final values slowly at low temperatures. The theoretical value is never obtained, but we remain about 1 per cent under. This confirmation was expected, for it is known that glass holds in solution a residue of Na_2SO_4, which cannot be further decomposed. Nothwithstanding the slow speed of dissipation of SO_3, this decomposition reaches its final value at the end of 20 minutes at 1300°. We shall return to this detail later.

Fig. 3. Curve representing ignition losses for varying periods of time with charges of increasing weights.



C. Experiment with a batch containing 50 per cent alkali in the form of sodium sulphate (Fig. 6). Experiment conducted as above.

The dissipation of CO_2 goes on almost without disturbance up to the final value which is somewhat lower than previously[3]. Dissipation of SO_3 is slightly more rapid but reaches the final value, for all the tempera-

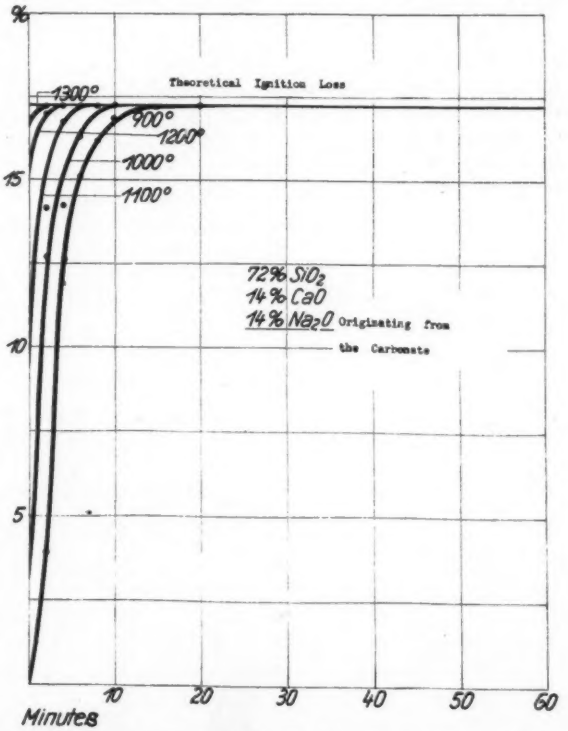


Fig. 4. Rate of speed of liberation of gases from a batch with a basis of sodium carbonate at various temperatures.

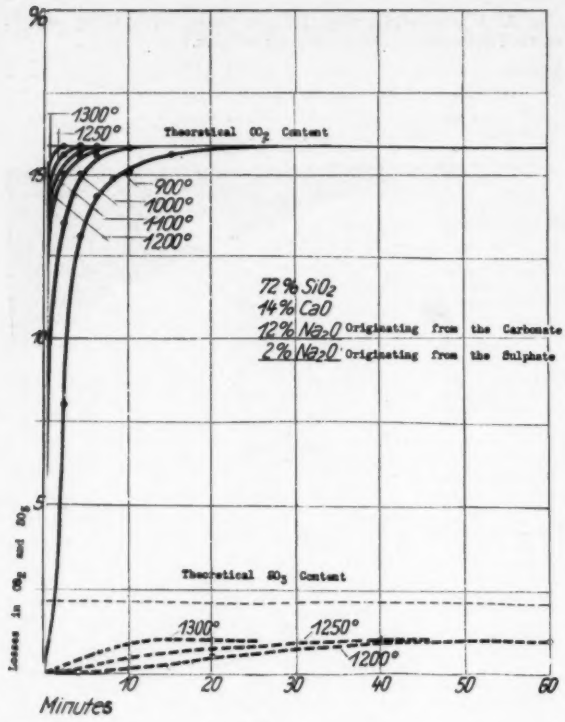


Fig. 5. Rate of speed of liberation of gases from a composition containing 2 per cent of Na_2O in the form of sulphate. Liberations of CO_2 and SO_3 are represented by different curves.

tures considered, only after a time longer than that of the experiments carried on with a minimum quantity of sulphate.

D. Fig. 7 refers to a batch restricted to sulphate. The quantity of CO_2 corresponds to the limestone. We note that the dissipation of SO_3 is still more rapid than in the experiments represented in Fig. 5 and 6. On the other hand, the final value of the residual SO_3 is always the same and remains 1 per cent below the theoretical calculated quantity and is therefore independent of the quantity of sulphate introduced at the outset into the composition.

We would be tempted to think that the partial pressure of SO_3 produced within the charge must in fact act to brake the reaction. Nevertheless, we must realize that it is a question of a reaction—between materials in a solid state—and not solely of a thermal dissociation. With an increasing concentration of sulphate in the sand —concentration acting as principal source of emission of gas, the surface of reaction is considerably increased, in such fashion that the products of dissociation are on the increase and not on the decrease as examination of the partial pressures would let it be supposed. Moreover, the possible and local formation of liquid elements ought to contribute to the more rapid liberation of gases.

E. The last question that presents itself relates to the rate of speed of the dissociation of the sulphate when brought into the presence of carbon, as occurs in practice. Following the preceding determinations we chose to introduce a quantity of charcoal equal to 5 per cent of weight of the sulphate. As it follows from Fig. 8 the curves are perceptibly straighter than in the analogous case, without charcoal (Fig. 7).

The reaction of $2Na_2SO_4 + C = 2Na_2O + 2SO_2 + CO_2$ is self-explanatory and this fact is numerically stated in the diagram. Comparing Fig. 7 and 8 we can conclude that the dissociation which takes place around 1300° is closely akin to that obtained at the nearest temperatures in industrial melts. This zone is shaded in Fig. 7. The charcoal introduced contributes thus to accelerate decomposition energetically. Nevertheless we should specify that we do not reach in this way in any instance the rapidity of decomposition of carbonates but that we approximate it by half.

In addition it seems that the formation of CO_2 following the preceding equation suffices to increase the pressure of CO_2 in the charge to the point of slowing down in a perceptible if not important fashion the emission of gas compared to that of Fig. 7.

What is worthy of note in the decomposition of sulphate in the presence of charcoal is the path of the curves, which at the outset mark a very sharp liberation then afterward a period in which liberation remains constant. This particular is noted above all at low tem-

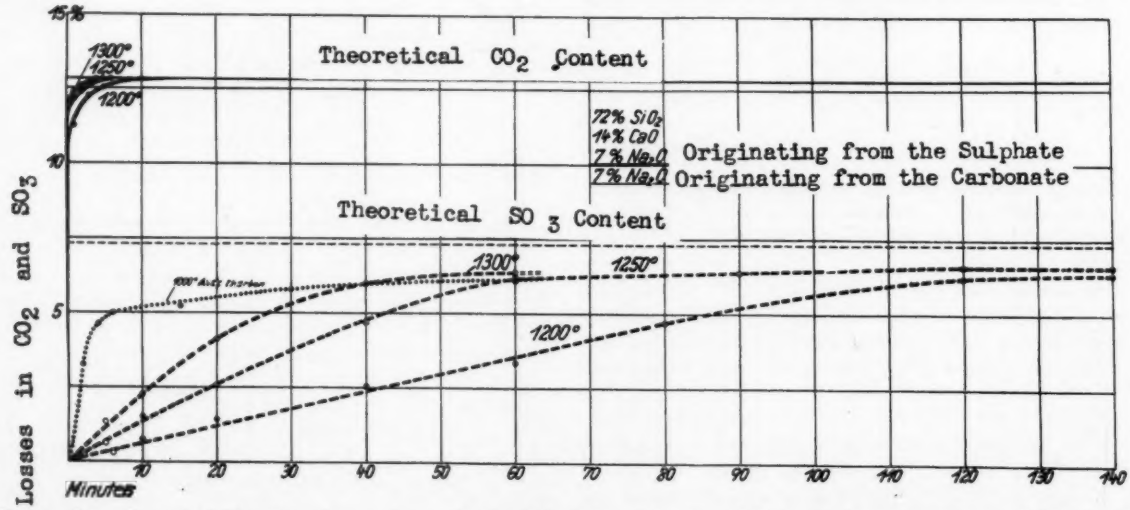


Fig. 6. Rate of speed of liberation of gases from a batch which derives its sodium half in the form of sulphate and half in the form of carbonate.

peratures and may be explained as follows: At high temperature the sulphate has in itself a tendency to thermal dissociation and is more susceptible on account of this disintegration to the action of charcoal. The curve is strongly ascendant and approaches rapidly enough to the limiting value of 1 per cent. At low temperature the sulphate is less susceptible to the action of charcoal which partially burns without being used, that is to say that only a part acts for the reduction of the sulphate and influences the reaction only during a certain time. The balance of the sulphate behaves otherwise. It dissociates itself without the aid of charcoal and reacts particularly slowly, above all since in the meantime a certain portion of the glass has formed and hampers the continuation of decomposition.

A comparison is now in order with the usages of practice which here find confirmation. There exists in principal order two ways of introducing sulphate into the composition, either in minimum quantity without charcoal or else in larger quantity with charcoal. We do not encounter the introduction of large quantities without charcoal, or in any case we ought not encounter them, for decomposition would be according to Fig. 6 so slow that we would be unable to achieve true refining. Conversely, we note that small quantities of sulphate without charcoal and large quantities with charcoal reach the final values almost at the same time, and show during the time the same rate of decomposition. This clarifies us on the precision of the reactions which take place in the melts, in research as well as industrially. A too rapid dissipation of gas leaves behind a large number of small wide-spread bubbles with insufficient liberation of gas remaining behind to carry them off (Fig. 9), conversely too slow a liberation pollutes the molten materials with bubbles.

This confirms that the action of sulphate of use in refining corresponds to that part of its decomposition which is not influenced by the charcoal, that is to say by the *excess of unreduced sulphate* the decomposition of which follows closely upon that of the carbonate.

It remains to examine the problem of bubbles found in a more advanced stage of the melt, which above all brings into question the behavior of residual sulphate in the glass, corresponding to the shaded field in Fig. 8. It cannot be overlooked that this residual sulphate exists, in part, even in the melts made solely beginning with carbonate, for it has been demonstrated and confirmed many times previously that traces of sulphur in the gases of combustion suffice in presence of oxygen to introduce into the melts a certain amount of SO_3 and to cause at times even the presence of "salt-water" on the glass.

Concerning the residual SO_3 in the glass we refer you to certain of our previous work[4] which discloses its behavior under varied conditions, which allows us to compile a practically complete table of the role of sulphate in melts and molten glass.

3. Comparison between raised temperatures in course of experiments and those noted in a charge of glass handled industrially.

IN ORDER to determine the range of temperatures which in the experiments come closest to those which correspond to the phenomena which develop in practice, it was judged necessary to proceed to measurements of temperatures in the charges of a furnace. No precise facts existed on the temperatures which prevail in the interior of a charge. We rigged, to this end, a Pt.-Pt. Rh. couple with a solder having almost no retarding influence, a couple which it was possible to place in a charge newly introduced into a furnace with a doghouse, the couple being placed on a level with the upper rim of the tank. The results are reproduced in Fig. 10.

The first readings at a 50 cm. depth in the charge show in the first 30 minutes a slight heating up to 70° C. At 75 cm. depth this temperature scarcely exceeds 100° although the charge floats on an incandescent mass.

After this sufficiently astonishing result we determined the highest temperatures to which a charge is subjected. This was done by advancing the pyrometer up to the moment when it encountered a resistant crust, then by making it penetrate this crust. The temperatures are, in a general way, scarcely higher than 1300° C. while simultaneously a pyrometer placed in the crown of the furnace registers 1420° C.

Finally, we determined in how much time the layer of the charge located 100 mm. from the surface of the charge directed toward the fire attains this same temperature. It is not until after six minutes that the assent is sharp, the temperature reaching 100° C. after 10 minutes and it is not until after 20 minutes that it ap-

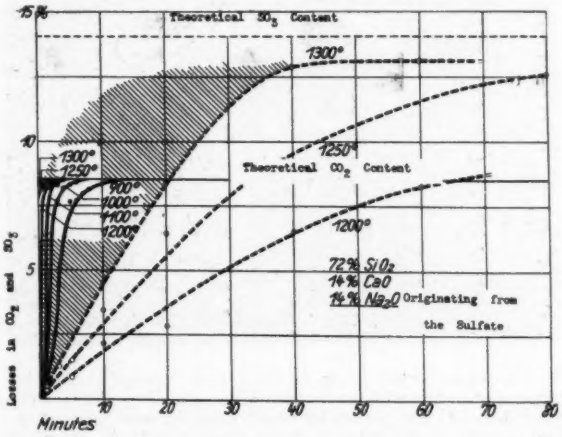


Fig. 7. Rate of speed of liberation of gases from a composition deriving all its sodium from sulphate. The shaded portion is to be compared with modifications shown in Fig. 8.

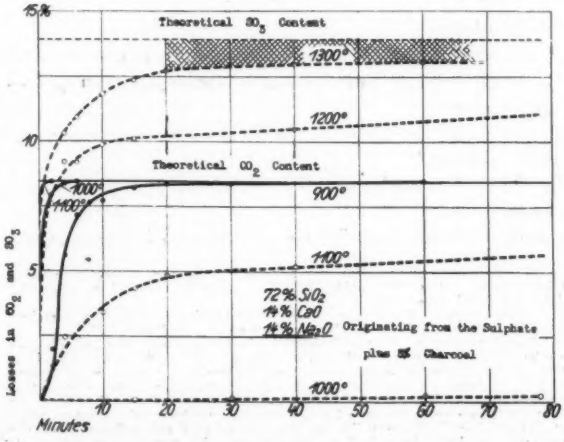


Fig. 8. Rate of speed of liberation of gases from a batch restricted to sulphate and containing carbon in sufficient quantity. The shaded zone shows the SO_3 remaining in the melt.

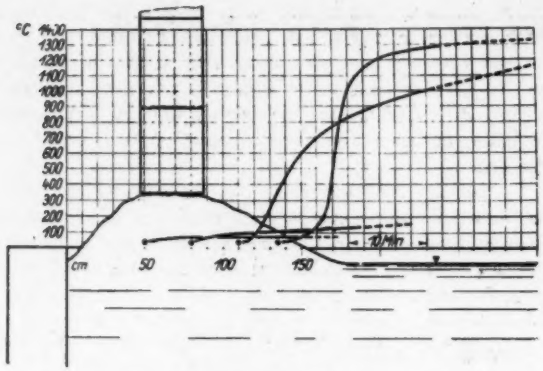


Fig. 9. Variation of temperatures taken in the interior of a charge put into an industrial furnace.

proaches 1300° C. Assuming that all the diagrams reveal that in this lapse of time small quantities of batch are melted between 1100 and 1250, it is evident that the batch has melted perfectly well below 1300° C., perhaps even at 1200° C. At 30 cm. in the interior of the charge, on the side of the flames, the rise of temperature is slower, reaching 500° C. after six minutes, 700° C. after ten minutes and 1000° C. after twenty minutes.

We must admit that once the charge has been pushed into the furnace, in order to make room for a new charge, the temperature can increase more rapidly. But on account of the poor thermal conductivity of the interior of the charge, it may be presumed that the major portion of the latter does not undergo very sensible modification in the curve of the temperatures.

It results, therefore, that the temperatures around which the reactions evolve are more nearly in the neighborhood of 1200° C. than 1400° C. as the ruling temperatures of the furnace could make it seem. Rather, it is those portions of glass melted at lower temperatures which become heated afterward to arrive at the refining temperature.

This comparison with industrial data enables us to conclude that the experiments made to examine the development of the reactions in a crucible correspond at all points to those which conform with practice. In particular the differences in rates of speed noted at the moderated temperatures of the experiments remain true for conditions existing in practice.

Recapitulation.

The preliminary experiments have shown:

1. That the mass of the batch, in proportion to free surface;
2. That the partial pressure of the atmosphere directly above the batch;
3. That the total mass, by reason of its low thermal conductivity,

exercise so great an influence on the rate of disintegration of the batch that according to the circumstances the variations may reach those brought about by spreads of 100° C. of temperature.

The principal experiments permit us to recognize:

1. That the study of the phenomena of flux between temperatures from 900° to 1300° C. presented a table the application of which is equally valid in principle for higher temperatures.
2. That liberation of SO_3, compared to disintegration of the carbonate occurs in relatively slow fashion, but is rather briskly accelerated by an increase in the concentration of sulphate in the mixture, thanks to the increase in the reaction surface.
3. That, contrary to the action of the carbonic acid, the release of SO_3 does not occur to the extent of reaching the theoretical value, but only up to a known residue of 1 per cent (the behavior of which is of primary importance for bubbles in the melt), and that it does so independently of the amount of sulphate originally contained in the batch.
4. That small quantities of sulphate without charcoal, considering the slight discrepancy of the limiting value of decomposition, or large quantities of sulphate with carbon, by virtue of their more rapid disintegration, produce as far as time is concerned the same effects in the development of the melt, which likewise corresponds to conditions recommended in practice.
5. That by addition of charcoal, especially at low temperatures, only the initial liberation of SO_3 is accelerated, while the balance passes off slowly. This is due to the charcoal, at low temperatures, being partially consumed without effect, before it attacks the sulphate; at high temperatures, thermal dissociation of the sulphate helps make the transformation complete, and likewise more efficacious.

The proposal to house New York City's exhibit at the 1939 World's Fair in glass met with the enthusiastic support of Mayor Fiorello La Guardia. His Honor said a glass house would be "in keeping with the policy of our administration where everything is in the open."

● The Consolidated Lamp & Glass Co., Coraopolis, Pa., has resumed production of its famous Catalonian line of glassware, which is a 20th century replica of the beautiful ware made in the 17th century in the province of Catalonia, Spain. It was noted for its unique design and for the myriads of scintillating bubbles diffused throughout the glass. Artistic crudeness is the underlying theme both of the old Spanish glass and its modern counterpart

[1] W. E. S. Turner: The scientific bases for the fusing of glass—*Glastechnische Berichte* 1931 No. 3. pages 151 to 166—cites 81 Bibliographical references.

[2] G. Tamman et W. Olsen: Die Reaktionen beim Zusammenschmelzen von Glassatzen. Z. Anorg. allgem Chemie 193 (1930) P. 245.

[3] Translator's note: Texts based on an over-abundance of detail give evidence of a certain volatility of their own. The Belgian original, at this point, distinctly appears to have suffered an emission of meaning. Perhaps in the author's heat of revision, the composition encountered "ignition losses" exceeding even the limiting value of 1 per cent which we were instructed to anticipate. Perhaps this is an instance of "ejecta loss." Regretfully, but for the sake of the refinement of the product, we have here had to reconstitute the composition somewhat, hoping all the while that we have injected no new ingredient into the meaning.

[4] H. Jebsen Marwedel et A. Becker: "Der SO_3 Gehalte des Glases." Glastechnische Berichte 8 (1930) No. 9, page 525.

ACCIDENTS IN THE GLASS INDUSTRY IN 1935

ALTHOUGH the accident frequency rate in the glass industry during 1935 showed a slight increase over the rate for 1934 the severity rate improved considerably according to the National Safety Council. Reports were assembled from 43 glass plants whose employees worked a total of 51,023,000 man-hours. The 1935 average frequency rate of 9.35 (the number of disabling injuries per million man-hours of exposure) is 2 per cent above the rate for 1934; but the corresponding average severity rate of 0.79 (the number of days lost per thousand man-hours of exposure) is 25 per cent below the 1934 rate.

The glass industry stands eighth in frequency of accidents among 30 major industries, being tied in this rank with the machinery industry; and it is also tied with the same industry in seventh place in severity experience. The average frequency rate of all-industries is 14.02, and the average severity rate 1.58.

The frequency of disabling injuries has decreased 39 per cent since 1929, in comparison with a reduction of 47 per cent for all-industries; and in severity the improvement is 24 per cent against an average reduction of 33 per cent for all-industries. Both 1935 injury rates are much lower in large units than in small ones. Large plants also had the best experience in comparison with 1934.

Manufacturers of incandescent lamps and radio tubes continue to have the lowest rates in the industry, averaging 3.32 for frequency and only 0.05 for severity. Plants manufacturing flat drawn glass, however, made the best showing in comparison with 1934 by reducing frequency 12 per cent and severity 19 per cent.

The most important type of compensable accident in the glass industry is "handling objects," which accounts for 40 per cent of all types and outnumbers any other single type by almost 3 to 1.

Glass plants had a better 1935 severity standing, in comparison with other industries, than they had in 1934. Frequency is 33 per cent below the 1935 average for all industries; severity, however, is now down 58 per cent. The industry has not kept pace with others in improving its accident experience over a period of years. The reduction of 25 per cent in severity from 1934 to 1935, however, was more than twice the average improvement for all industries. All types of injuries have decreased in both frequency and severity since 1929. The largest improvement has been made in the frequency of serious injuries but this improvement has been accompanied by only a slight decrease in the severity of permanent partial disabilities.

	Frequency		*Severity*	
Type of Injury	1935 *Rate*	*Per cent Reduction since* 1929	1935 *Rate*	*Per cent Reduction since* 1929
Death & Perm. Total	.08	41%	.48	41%
Perm. Partial	.37	44%	.16	1%
Temporary	8.90	38%	.15	6%
Total	9.35	39%	.79	24%

Small plants had the highest 1935 injury rates, which were also up sharply in comparison with 1934. Credit for the good standing of the industry, in comparison with other groups, belongs, therefore, to the large units.

Size Group	1935 *Frequency Rate*	1935 *Severity Rate*	1934-1935 *Change in Frequency*	1934-1935 *Change in Severity*
Large	8.68	.53	—12%	—49%
Small	20.51	3.06	+22%	+85%

Plants manufacturing flat drawn glass had the worst record for 1935, averaging 10.57 for frequency and 1.20 for severity. Credit for achieving reductions over 1934, however, goes to flat drawn glass plants, as shown below:

Classification	1934-1935 *Change in Frequency*	1934-1935 *Change in Severity*
Entire Industry	+ 2%	—25%
Flat Drawn Glass	—12%	—19%
Incandescent Lamps and Radio Tubes	+76%	—77%
Glass Products	0.0	—33%

During the last two years, companies having fatalities or permanent partial disabilities have been requested to make a special report on the circumstances involved in such injuries so that better information could be developed on the fundamental causes of serious accidents in the industry. Summary reports for the last two years have listed 47 serious injuries and 23 of these cases have been reported in detail. An analysis of the circumstances involved in these injuries discloses:

1. Repair and maintenance men, supervisors and technical employees, and laborers were involved in more serious accidents than other occupations.

2. Machinery was the most important agency of injury and was followed in importance by elevators and hoisting apparatus. The latter equipment was involved in the death of four men, one of whom was fatally injured when he climbed on a bench and put his head into a partially enclosed elevator shaft.

3. Employees received serious injuries mostly when members of the body were "caught in or between" moving parts of machinery and hoisting equipment. A typical accident of this type occurred when an employee attempted to loosen a jammed chain by grasping it too close to the sheave. Other important types of accidents were "falling, sliding, flying objects" and "struck against."

4. "Improper guarding" and "defective substances or equipment" accounted for almost half of the 23 serious injuries. An electrician, for example, was turning down a grease cup located on the inside bearing of a fan when his hand slipped and struck the blades, which were only partially guarded. This accident cost $700 in compensation and medical care.

5. The principal personal causes of these 23 serious injuries were inattention, disobedience of instruction, chance-taking, lack of knowledge or skill. Failure to load pans on a truck in accordance with instructions resulted in the partial loss of a finger and cost $175 in compensation and medical expense and in another accident, the penalty paid by an employee for insufficient knowledge about the operation of a hoist was the partial loss of his right index finger; plus a cost to the company of $130 in compensation.

The following table gives a percentage distribution of cases (nearly all compensable) covered in recent

one-year reports from Illinois, New York, Maryland, New Jersey and Pennsylvania. These reports covered 224,661 injuries in all-industries and 554 injuries in the manufacture of glass products:

Type of Accident	*Per Cent in All Industries*	*Per Cent in Glass Products Industry*
All types	100.0	100.0
Handling objects	25.9	40.3
Falls to a different level	8.7	6.5
Falls to the same level	9.5	5.8
Machinery	12.0	14.4
Vehicles	10.9	2.9
Using hand tools	7.6	2.5
Falling objects	8.7	3.6
Stepping on or striking against objects	5.6	7.8
Electricity, explosives, heat	3.6	4.3
Harmful substances	2.1	4.9
Other	5.4	7.0

The National Safety Council has listed the following plants as worthy of mention for outstanding safety achievement during 1935:

Pittsburgh Plate Glass Co. Works No. 12 at Clarksburg, West Va., had the lowest 1935 frequency rate among large units, 2.26; also the lowest severity rate, 0.05; also the largest improvement in frequency from 1933 to 1935, 86 per cent; also the largest improvement in severity from 1933 to 1935, 98 per cent.

Corning Glass Works. The Rhode Island Division has the best 1935 record, 150,000 man-hours without a disabling injury.

Hygrade Sylvania Corporation. The Hygrade Lamp Division has made the largest improvement in frequency from 1933 to 1935—62 per cent; also the largest improvement in severity—98 per cent.

Owens-Illinois Glass Co. Factory No. 3, Fairmont, West Va., has the lowest 1935 frequency rate among large units, 2.09. Factory No. 14, Bridgeton, N. J. has the lowest 1935 severity rate among large units, 0.07. Factory No. 17, Clarion, Pa., has the best 1935 record among small units, 611,000 man-hours without a disabling injury; also the largest improvement in both injury rates since 1933, 100 per cent.

G. C. A. TO MEET IN SEPTEMBER

Plans for the fall meeting for members of the Glass Container Association have been approved by the board of directors of the Association. The meeting is scheduled for Sept. 23, 24 and 25 and will be held at the Ambassador Hotel, Atlantic City, N. J. The schedule of meetings is as follows:

Wed., Sept. 23, A. M.—Board of Directors Meeting
Thurs., Sept. 24, A. M.—General Association Meeting
Fri., Sept. 25, A. M.—Glass Division Meeting.

Arrangements are being made with the Seaview Golf Club for those who care to play golf the afternoon of Sept. 24. There will also be dinner and dancing Thursday evening.

GLASS DIVISION MEETING IN OCTOBER

The Glass Division of the American Ceramic Society will meet in Cambridge Springs, Pa., on Oct. 23 and 24. The meeting will be somewhat different from the summer meetings heretofore held at Lake Keuka. The program on Friday will consist of reports from delegates to the International Congress on Glass which was held in London. They will give their impressions of the work being done abroad. A feature of the gathering will be the presentation by Francis Flint of some stereoptican slides which he made in England. A golf tournament will be held on Saturday, the 24th.

"THE GLASS INDUSTRY" IN LARGER OFFICE

Need for additional office space for The GLASS INDUSTRY and its sister magazine, *The Glass Packer*, has made necessary the removal of these publications to new and larger quarters. Effective Aug. 31, the address of The Glass Packer will be 11 West 42nd Street, New York City. The new offices are on the 22nd floor of the Salmon Tower, a modern building close to the corner of Fifth Avenue and 42nd Street, "the crossroads of the world." Opposite the New York Public Library and a short walk from the Grand Central Terminal "glass headquarters" is located within easy reach of both the downtown and mid-town business sections and will be very accessible for out-of-town visitors. It is close to the offices of many glass companies in the midtown district. A cordial invitation is extended to all readers of this magazine to call on the publisher and staff in their new home. Room 2270; telephone: PEnnsylvania 6-4109.

GLASS CLAD BATTERIES PRODUCED

The National Battery Co., St. Paul, Minn., is reported to be planning to place on the market a new battery for automobiles, which will employ spun glass porous mats to retain the active lead particles in the plates.

The glass-clad battery demonstrates one of the newest successful applications of fibrous glass for manufacturing purposes. Capable of double the life of batteries formerly on the market, the scientific principle behind this invention depends on spun glass for its success.

The battery is clad with two flexible and highly porous retain-mats made of many layers of finely spun glass which are placed against both surfaces of the positive plate. The heart of the storage battery consists of the active material, that is, lead particles on the plate on which the electrolyte acts. As the lead particles drop away from the plate with continued vibration and wear, the life of the battery shortens. The laminated glass mats hold the particles to the plate while at the same time their porosity permits a free supply of acid to the entire surface of the plate and in no way obstructs the passage of the current. These spun glass mats are said to give from 50,000 to 225,000 miles of service.

The Owens-Illinois exhibit at the Texas Centennial, Dallas.

TRENDS IN INTERNATIONAL GLASS RESEARCH

By SAMUEL R. SCHOLES

Although the papers and discussions at the recent Congress covered a wide range, practically the entire field of glass technology, from raw materials to decoration, it seems that the subject of greatest interest is that of properties; and here we are drawing a distinction between the behavior of glass-as-glass and glassware.

Recognition of the almost mysterious influence of surface conditions on mechanical strength and on chemical durability; of thermal history or heat treatment on coefficient of expansion; of design and method of production on the physical behavior of glass articles—all these now enter strongly into consideration.

While the problem of arriving at specific and accurate knowledge about our chosen material may seem to be made more complex and obscure by this admission of variables, there is in reality a clearing of the atmosphere. We agree upon the necessity for working upon comparable specimens, of simple, reproducible form. We can co-ordinate and justify apparently discordant results from separate laboratories. And we can eventually, by standardization of specimens, heat-treatments, and experimental methods, arrive at the accumulation of truly scientific data.

Without adverse criticism of foreign glass technologists, it seems worthy of remark that the American approach to the problem of physico-chemical measurements is being very carefully made. Americans appear to be more concerned with methods than with results, and to be anxious for critical data, rather than for accumulations of uncertain numbers. The report of the A. S. T. M. sub-committee on mechanical strength recited a range of values that brought forth expressions of astonishment. But the frank discussion of such variations can eventually bring glass technology nearer to real information on the strength of glass than could the publication of meaningless "means" arrived at by unjustifiable arithmetic.

Our researchers are realizing that much of the attack of physical measurement upon glass has been like the storied inspection of the elephant by the blind men. The present effort is devoted to seeing the material clearly and seeing it whole. Methodology must be the aim for today, if useful facts are to emerge for the exacting technology of tomorrow.

● Scenes from the International Congress. Right, Photographer Hettinger bounces a glass bulb.

● More I. C. G. scenes from London. Factories, banquets, exhibits, not to mention the streets of London and Oxford, all added to the meeting.

If this attitude is not a very bold one, neither is it reckless. It does not expect scientific accuracy from measurements whose basis is not completely scientific. It does not assign values in three or four significant figures to the physical properties of a series of glasses whose compositions are uncertain in the first decimal place, and whose homogeneity is by no means established.

The homogeneity of specimens made from small experimental meltings will always be open to question, until we regularly follow some such procedure as that of optical-glass manufacture, or the painstaking method used by the Geophysical laboratory. Carrying out measurements on a large number of specimens is only a makeshift.

This lack of confidence in our measurements that is a consequence of more intimate knowledge of the wayward character of glass as we make it may be to blame for a conspicuous lack in American contributions to the literature. This is, the scarcity of generalizations, particularly mathematical ones. While we in the Glass Division are still attempting to decide upon a method competent to measure the rate at which a glass is attacked by water, Germans like Keppeler and Berger announce a parabolic law to express the relation between solution and time. We demonstrate that the accuracy of strength tests is so grievously affected by surface conditions that results can be only approximate, at the same time calling attention to the remarkably large strength moduli obtained with very small specimens, while

Hampton of England promulgates an inverse-square-root law for diameters and moduli.

Perhaps this American way is too cautious, and too negative, and we merely see too many lions in the road. Perhaps, too, the conservative way is the better, and we shall generalize more soundly when the returns are all in and checked. At any rate, these differences are discernible between the tendencies on opposite sides of the Atlantic. The traditional slap-dash of America is by no means gone, but it can certainly not be considered characteristic of our glass technology of today.

Although all of the technical papers read before the Congress have not yet been released for publication, The GLASS INDUSTRY plans in the future to publish resumes of the material discussed so that its readers may keep in touch with research throughout the world.

The paper presented by Dr. Tech. Ing. J. Polivka of Czechoslovakia, in Group IV of the International Congress, seems worthy of an extended abstract.

New Developments in Glass for Constructional Purposes.

Glass has the valuable properties, in addition to its transparency, of great durability (against weathering), wealth of color, and fine gloss. In architecture, glass has found no strictly new uses until very recent developments have created new demands upon windows.

These new tasks for glass are listed as follows:

(1) Heat insulation for economical heating and air conditioning, involving the problem of "sweating" surfaces;

(2) Sound proofing against noise;

(3) Prevention of glare from sunlight;

(4) Diffusion and refraction of daylight, and consequent better distribution;

(5) Selection of light, as by polarizing glass, for better use and comfort;

(6) Constructions of reinforced glass, concrete and supporting glass members;

(7) In glass bricks, better regulation of internal strain, and insulation against noise;

(8) Greater strength in large glass plates;

(9) Glass devices for utilizing zenith light;

(10) Reduced risk of breakage in wall coverings and floor members of glass.

These are discussed in detail as follows:

(1) The conductivity of a clear glass plate is about the same as that of an ordinary brick wall. But the wall is much thicker, and consequently a better insulator. However, increasing the thickness of the plate five times improves its insulating value only three per cent. Double windows, with air space give improved results; a vacuum space between panes is of no advantage.

A new insulating glass called "Thermolux," having two clear panes with a layer of regularly arranged glass threads between, has only 1/7 to 1/6 the conductivity of clear glass.

(2) The resistance of glass to sound depends upon the rigidity of the sheet, and can be augmented by double glazing—effective up to an air space of two inches, and very effectively by using spun glass between two panes. Such a compound glass, mentioned as "TX," reduces the (air-borne) sound of a motor horn (80 decibels) to an extent that conversation is not disturbed (40 decibels). Double glazing with TX would practically silence such a sound.

(3), (4), (5) Glass for diffusing light has been produced by altering the surface, as by grinding, etching, or figuring, also by including particles to produce a milky appearance. These particles are replaced by silky glass threads, in the TX glass. The problem is, to diffuse daylight in such a way as to carry it to the remote corners of a room, and to secure, without glare, a minimum intensity of 0.5 foot candle.

Mention is made of E. H. Land's "Polaroid," which consists of a flexible film a few thousandths of an inch thick, formed by suspending tiny crystals of herapathite, $(C_{20}H_{24}N_2O)_4 \cdot 3H_2SO_4 \cdot 2HI \cdot I_4 \cdot 6H_2O$, properly arranged (oriented) in a cellulotic medium, and sealed against moisture between panes of glass.

Another variety of polarizing glass is "Vitropolar" glass, a sandwich containing minute glass needles, set at proper angles. When two such panes are set up with the needles or tiny parallelopipeds at right angles to each other, all glare is eliminated.

(6), (7) Reinforced glass concrete, semi-transparent, becomes the subject of analytical study, and it is possible to estimate the strength in a practical manner. On the basis of these studies was worked out the glass-concrete cupola for one of the buildings at the Olympic stadium in Berlin.

(8) Methods and formulas are given for estimating the normal strength of large plates of glass, as against wind pressure. It appears possible to obtain actual engineering data.

(9) By suitable reflectors, zenith or actual sky light can be brought into rooms otherwise badly lighted by horizontal light.

(10) Many factors are cited as influencing the risk of breakage of glass in walls and floors. Methods for estimating the "shock hardness," by falling-ball test, and the "shock resistance," similarly, are discussed.

The complete publication of Dr. Polivka's paper may be awaited with interest.

RANDOM NOTES FROM LONDON

The following notes were culled from the backs of old envelopes found at the International Congress on Glass in London.

● Our mythical decoration for all-round brilliance goes to Berger; for personality to Maurach; for manly beauty to Long; for voice to Versen; for clear diction to Muhlig; for smiles to Ota; for the most chivalrous tea-speech to de Artigas; for the most entertaining lecture to Hostetter; and for maintaining the prestige and dignity of the American Ceramic Society, to Flint.

● Mysteries of orthoepy! The difference between the English and American languages is nowhere more apparent than in the word "glass" itself—if we except "la-baw'—rat'ry" and "shedule," and a curious twist to the long "o" as "gao."

● While conversation about prices was not at all general, it seems that the British are as much worried by outside competition, especially in hand-made ware, as Americans are.

● The Congress cabled to Jess Littleton their regrets over his inability to be present. His absence and that of George Morey were keenly felt by the Americans.

● The English bus-driver sits over the motor, drives with amazing skill, and misses even the multitudinous bicycles—always on the "wrong" side of the road.

● The Electrical Development Association room in the I. E. E. housed a fine demonstration of modern tube- and bulb-lighting effects.

● The "Hettinger Unit" for proper exposure of photographic films will soon be internationally standard among glass technologists.

● Standard form of address in Group II: "Mr. Chairman, Miss Dimbleby, and gentlemen."

● In London a subway is a tube, but a radio tube is a valve.

CLASSIFICATION OF TANK FURNACES

by Professor S. S. Berman

Best known of the several classifications for tank furnaces is that suggested by Professor Keppeler[1] which is based on two general principles. First is the method of utilizing the heat of waste gases for the heating of air or the heating of the air and combustible gases, i.e., the regenerative and the recuperative method. The second principle involves the direction of the flame in the combustion chamber of the furnace.

The first principle mentioned above may be enlarged upon depending on whether the air only or both the air and gas are heated. In recuperative furnaces only the air is heated while in regenerative furnaces both gas and air are heated. When operating with liquid fuels or so-called rich gases, only the air is heated while with producer gas, air and gas are generally, but not always, heated. Thus, two sub-divisions might be proposed for regenerative furnaces, namely: furnaces with two chambers which are supplied only with air regenerators; and furnaces with four chambers which include both air and gas regenerators.

The second essential point in Professor Keppeler's classification concerns the direction of flame in the combustion chamber of the furnace and affords a good deal of variations, especially insofar as recuperative furnaces are concerned.

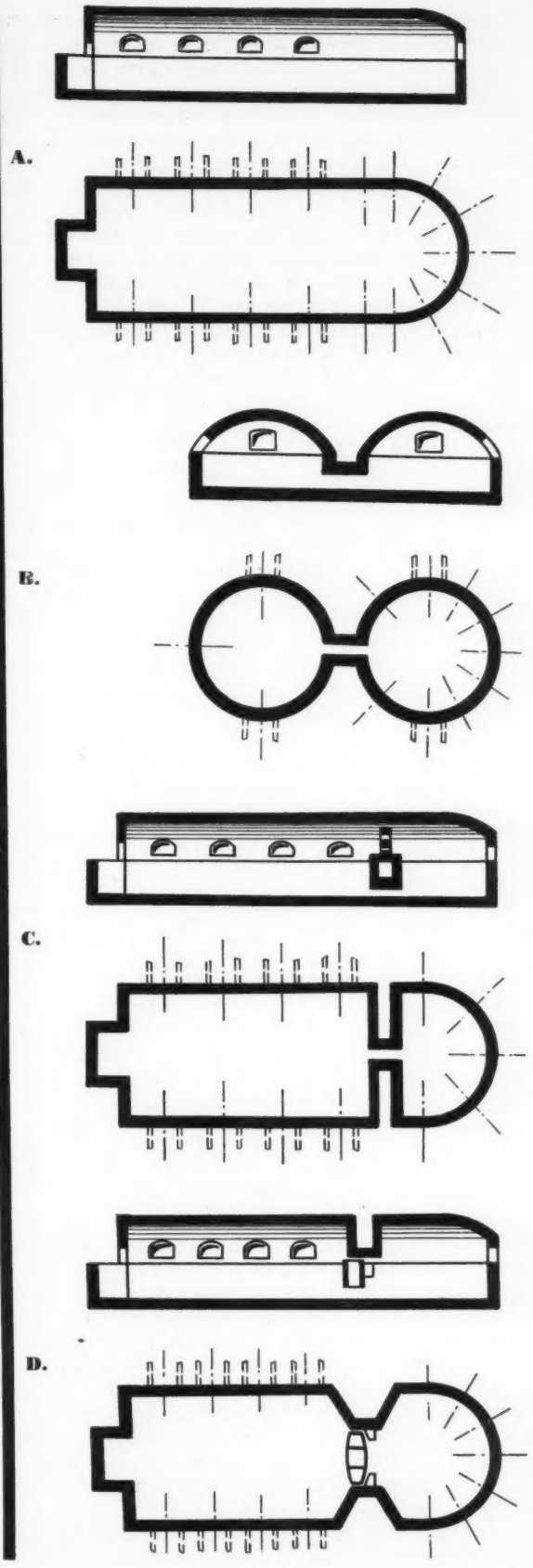
According to modern practice, however, there is one essential shortcoming in Professor Keppeler's classification in that he has dealt only with the old type tank furnaces with an undivided chamber in the tank proper. He does not cover the furnaces which have recently been adopted and which consist of a constructional division of the tank into separate zones. Obviously the question of adopting an undivided chamber or a divided tank has a great significance in determining the working index of a furnace, its routine and even its utility for different branches of the industry. For this reason, the present paper places first the problems of tank division.

Methods of Tank Division

Furnace with a single chamber—A tank furnace for continuous operation consists of four zones; namely, the melting proper, fining, cooling and working zones. If these zones are not divided constructionally, the furnace has a single chamber, the plan of which is shown in section "a" of Fig. 1. In such single chambered tanks, partial separation is often gained by installing barriers in the form of "floaters" in the glass mass and thus dividing it. However, despite these installations, the furnace is nevertheless considered as a single chambered tank.

Furnaces with divided chambers—The tank is usually divided into two parts: the heated part containing the melting and fining zones and the unheated one containing the cooling and working out zones. Although it

[1] Dralle Keppeler, Die Glasfabrikation, 1926, Munchen und Berlin, Bd. 1, 470-472.



● Fig. 1. Methods of tank division: A. A furnace with a single common tank; B. Malyshev's furnace ("wasp shape" tank); C. American throat furnace; D. Furnace with latent construction.

would be rather desirable from the theoretical viewpoint to separate the melting zone[2] from the refining zone, this idea does not find practical application today. The chief reason is that present-day materials of construction are not sufficiently resistant, without artificial cooling, to the corrosive action of the batch under high temperatures.

An arrangement of artificially cooled partition walls resistant to corrosion in the middle of the heated zone between the melting and fining zone is inexpedient because of the absorption of large quantities of heat. This results in a temperature decrease in that part of the furnace where such a decrease is absolutely undesirable. However, with the advent of "super-refractory" materials capable of withstanding corrosion in the melting zone, the desirability of a constructional separation of the melting and fining zone will no doubt be acknowledged.

Although in general the cooling and working out zones are combined, they are sometimes divided in mechanized glass production, as, for instance, in cases where the machines require a large frontage for working or when special demands are made upon the furnace regime. An example of such a separation is to be found in the canals of the Fourcault window glass machines. Another example is the special revolving "pot" used with some suction machines for making glass bottles.

Usually a Fourcault canal or a revolving pot is not considered as a part of the tank furnace but as a separate entity. The tank furnace itself is usually divided only into two parts, as already mentioned. This division may affect both the glass mass itself and the fire zone above, thus affording the possibility of different methods of division and different combinations.

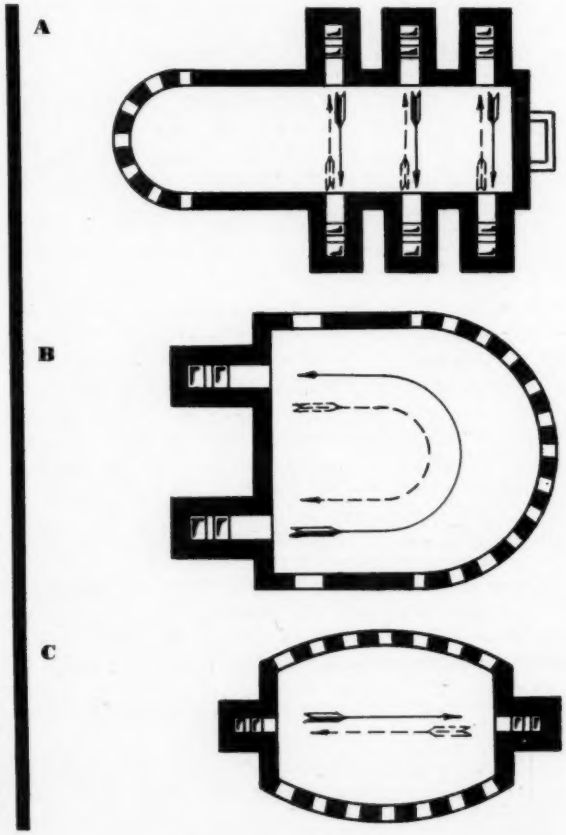
Fig. 1 shows three types of furnaces involving constructional divisions of great practical importance. The first of these, illustrated in section "b," shows Malyshev's furnace[3] with a wasp shape tank which was adopted in Russia on a large scale some 30 years ago. Here is a separation of the flame space and the glass mass. In fact, the furnace appears as two entirely separated basins each provided with a separate crown. In the first compartment, the so-called melting tank, the melting and refining of the glass mass takes place. It then passes through a low and narrow throat, sometimes called a dog-hole situated above the bottom of the tank, and then into the second compartment, which is the working end. The cooling necessary for the glass mass is accomplished partly in the dog-hole (throat) and partly in the working end.

Malyshev's furnace features the following: the fire zone is completely divided, both tanks possessing separate crowns; in the glass zone both basins communicate through a low and narrow throat situated near the bottom of the tank. Several scores of furnaces of this type were built 30 years ago for hand production and some of them are still in operation. Moreover according to Dralle Keppeler[4] two big furnaces of this type are producing glass mechanically.

Section "c" of Fig. 1 shows a second method of dividing the tank employed widely about 10 or 15 years ago in America and later in Europe. This is a furnace of the American type with a throat and consists of two tanks, the melting and the working end being connected in the zone of the glass mass, as in Malyshev's furnace, by means of a dog-hole of very small section.

The principal difference between Malyshev's furnace and that of this American design lies in the construction of the crown. The former has a separate crown for each tank while the latter has a common crown for both tanks. In other words, the flame space of Malyshev's furnace is divided into two parts while in the American furnace with a dog-hole it is common for both tanks. However, in the American construction, the flame zone may be divided into separate compartments by installing a more or less close checker wall ("shade wall") on the top of the upper bridge wall. But usually such a wall is either open checker-work or does not reach the roof, thus leaving the flame spaces of both tanks connected. Furnaces of this type are used particularly in the mechanical production of bottle glass and tableware.

Section "d" of Fig. 1 shows a method of dividing the tank which has been worked out by the author for the mechanical production of window glass. The furnace consists of two separate compartments connected by a waist or constriction, caused by a narrowing of the tank. The waist differs from a throat in two ways: first, it is much broader than a dog-hole, and, second,



● Fig. 2. Flame direction in regenerative tank furnaces: A. Cross fired furnace; B. Horse-shoe fired furnace; C. Longitudinally fired furnace.

[2] The constructional division of a tank furnace into three chambers had already been carried out by Siemens in the middle of the last century in his first tank furnace for continuous operation. See Benrath, *"Die Glasfabrikation,"* 1874, 150-153.
[3] Russian Patent No. 5921, issued Oct. 30, 1901. Applied Feb. 17, 1897.
[4] Dralle Keppeler, "Die Glasfabrikation," Munchen und Berlin, 1931, Bd. II, 1120-21, fig. 1127 & 1129.

it extends through the whole depth of the glass mass. A floater, which is usually not long but rather deep and has a variable depth of immersion, is placed in the waist. Both compartments are covered with separate crowns which join with the crown above the constriction, placed just above the glass level. A passage can be cut through this crown for the installation of a fixed or movable bridge. This affords a means either of regulating the communication between the fire spaces of the two basins, or of separating the latter entirely.

In brief this section on methods of tank division, which has been illustrated in Fig. 1, may be summarized by dividing all tank furnaces into two main types of furnaces: namely, those with a single common basin and those with separate basins. The second category may in turn be divided into three principle types according to the method of division of their tanks. They are: first, furnaces with a dog-hole and separate crowns (Malyshev's furnace with a wasp shape tank); second, furnaces with a dog-hole (throat) and one common crown (the American design); and third, furnaces with a lateral constriction.

Besides these methods of tank division, other different designs are sometimes used, particularly as regards the arrangement of division walls with artificial cooling. However, none of these methods has found wide practical application.

Utilizing the Heat of Waste Gases

ANOTHER factor in tank furnace classification is the method of utilizing the heat of waste gases for the heating of air (and often of gas also). This involves the adoption of regenerators and recuperators for this purpose. Each of the furnaces in Fig. 1 can be supplied either with regenerators or recuperators. Eight combinations are thus possible. For a number of reasons recuperators are used only for the heating of the air required for combustion. In regenerators both air and gas can be heated. But since there can be air as well as air and gas regenerators, the number of combinations increases up to twelve.

The four fundamental types of tank furnaces represented in Fig. 1, when supplied with regenerators, have a wide practical application. Only two types of tank furnaces are known to be supplied with recuperators: the furnaces with one common basin and the American furnace with a throat. All the wasp shape and laterally constricted furnaces, known to us, are supplied with regenerators, although no obstacles are encountered in building these furnaces with recuperators.

Flame Direction in Furnaces

A GREAT number of variations present themselves in this important classification for tank furnaces, especially where recuperative furnaces are concerned. The principle variations of flame direction for regenerative furnaces are shown in Fig. 2 and for recuperative furnaces in Fig. 3. It should be noted, however, that for reasons of simplification, these drawings are for a single chamber furnace, although all these variations might equally well be applied to any type of furnace with a constructionally divided tank.

Flame direction in regenerative furnaces—Fig. 2 shows the three principal directions of the flame in regenerative furnaces.

In section "a" showing the so-called cross-fired, the flame gases move perpendicularly to the length of the furnace first in one direction (unbroken line) and then after the reversal in the opposite direction (broken line). The pots are situated lengthwise to both side walls of the furnace. The cross-direction for the flame is mostly used in regenerative furnaces and may be adopted for all the four principal types.

Section "b" of Fig. 2 shows the so-called horse-shoe direction and is characterized by two burners situated in the end wall. The flame goes from one port, moves along the furnace, then turns in the opposite direction and enters the second port (unbroken line). After the reversal the flame enters the furnace in the opposite direction (broken line). Although this horse-shoe direction is less common than the cross direction, it is often applied in small furnaces, especially when liquid fuel is used. It has also been proposed to utilize this principle for large furnaces but it has not met with general approval.

The third method of directing the flame is the longitudinal one shown in section "c" of Fig. 2. The ports are situated in both end walls. The flame moves lengthwise along the furnace first in one direction (unbroken line) and then, after reversal, in the other direction (broken line). The longitudinal direction of the flame is usually adopted for small tank furnaces of periodical operation. Sometimes it is used for small single chamber continuous furnaces, but in these cases one is obliged to work with "boots." In recent years, there have been suggested several designs for tank furnaces with divided basins and a longitudinal flame direction.

As a matter of fact furnaces with a longitudinal flame direction are used comparatively seldom for melting glass, but are often applied in metallurgy as exemplified by the Siemens Martens furnaces.

Flame direction in recuperative furnaces—Fig. 3 shows seven different directions which the flame may take in recuperative furnaces. The first four shown are most popular for furnaces with single chamber as well as for furnaces with separate basins. The fifth and sixth types are used comparatively seldom, while the seventh type has begun to find general recognition in recent years. (*It is reported from another source that this seventh type of flame direction has been tried in America by two or three firms and abandoned by them.—Ed.*)

The first type, shown in section "a" of Fig. 3, is characterized by the presence of two ports at the end wall. The combustion gases move in two flows along the longitudinal walls and then turn back in one common current in the direction of the furnace axis entering thereafter the central draw-off port situated in the middle of the end wall. Recuperative furnaces with such a flame direction are described as furnaces with a "double inwardly turning horse-shoe flame." When supplied with a common basin, they are sometimes called "Sticzynski furnaces."

In section "b" the entrance port and two draw-off ports are again situated at the end wall. This type differs from that in section "a" which has only one central burner port situated on the axis of the furnace. The combustion gases move along the axis and then turn aside outwardly in both directions, following an opposite course along the sidewalls. They then enter

the draw-off ports situated at the end-wall on both sides of the burner. It is called a "double outwardly turning horse-shoe flame." When provided with one common basin, they are frequently called Nehse-Dralle's Furnaces[5].

The third type of flame direction in a recuperative furnace is shown in section "c" of Fig. 3 and is known as a "longitudinally fired furnace." It is characterized by one or two ports at the end wall and two draw-off ports in the side walls.

In the fourth type, section "d," the ports are situated in the side walls rather than in the end wall. There are one, two or more ports in each side wall. The combustion gases coming from opposite directions meet in the center of the furnace. Then after turning aside run the length of the furnace turning again and finally entering the draw-off ports which are also located in the side walls. These may be called "furnaces with a cross horse-shoe direction of flame." Furnaces of this type with a dog-hole tank division are built by the English designer Teisen and by Stein and Atkinson[6].

The construction (section "e") of the fifth type with a cross flame is inexpedient owing to the asymmetry of the fire flow relatively to the longitudinal axis of the furnace, which is of great importance in recuperative furnaces. If several burners are installed in the longitudinal walls, the direction of flame according to type four (section "d") is much more expedient.

The sixth type[7] (section "f") "with a longitudinal and cross horse-shoe flame" is seldom used.

The seventh type, (section "g") with a double crown is designed by the Amsler-Morton Co. Its distinctive feature is the presence of a double crown. The combustion gases after having entered through a port in the end walls of the furnace run along the latter not far above the glass level toward the working end. From here they pass through the space between the inner and outer crown and passing into the draw-off ports enter the recuperator. Furnaces of this type have begun to achieve general recognition during recent years, since they possess important advantages. This type may be called a furnace with "vertical horse-shoe flame."

Summarizing all that has been said as to the classification of tank furnaces, it is evident that there are many types of furnaces. The principal features in the classification so far are:

a.—The presence of a single chamber tank, or of several, and the method of their division (Fig. 1).

b.—The presence of regenerators and recuperators.

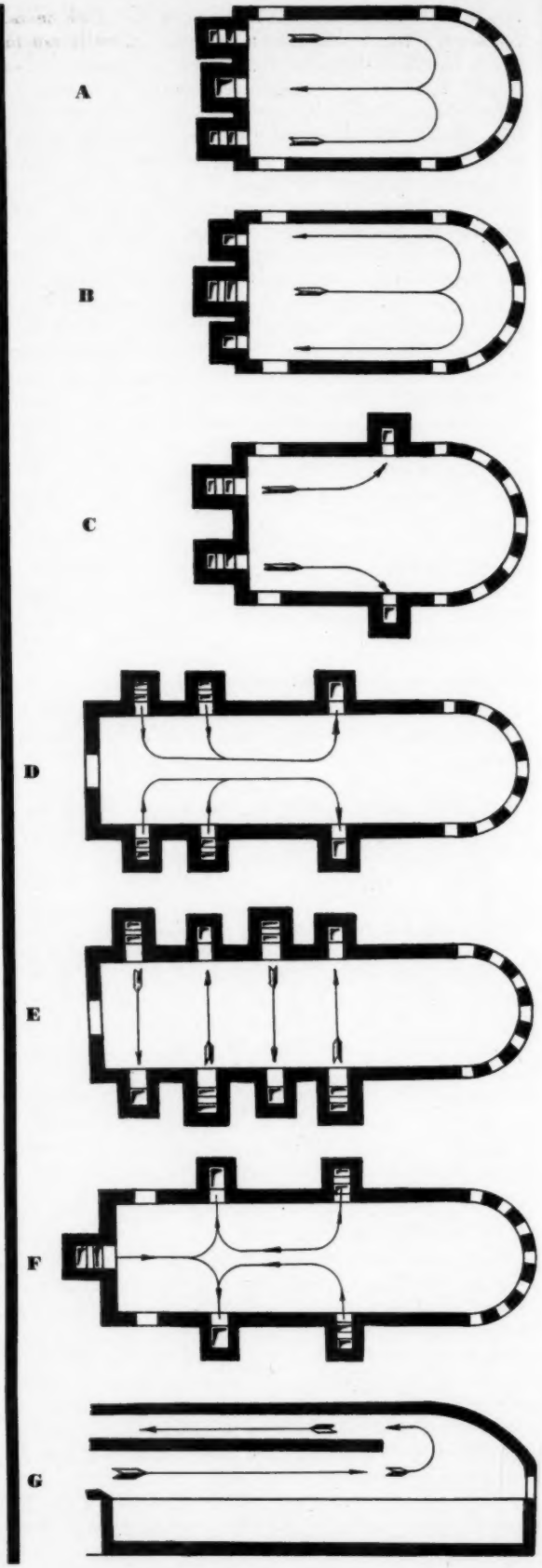
c.—The direction of the flame (Figs. 2 and 3).

All the possible combinations seem to afford a large number of different furnace types. But in reality there are not so many variations and the majority of the working tank furnaces are built accordingly to a small number of types.

(This article on tank furnaces will be concluded in October.—Ed.).

[5] Dralle Keppeler, "Die Fabrikation," Bd. I, Munchen und Berlin, 1926, pp. 474-5, Fig. 351-2.

[6] F. W. Hodkin nd A. Cousen, "A Textbook of Glass Technology," fig. 149 and 150.



● Fig. 3. Flame directions in recuperative tank furnaces: A. Double inwardly-turning horse-shoe flame; B. Double outwardly-turning horse-shoe flame; C. Longitudinally direction of flame; D. Cross horse-shoe flame; E. Cross flame; F. Longitudinal and cross horse-shoe flame; G. Double crown (with vertical horse-shoe flame).

PAPERS OF INTEREST TO GLASS MEN AT ILLUMINATING ENGINEERING SOCIETY MEETING

DURING the week of Aug. 31 the city of Buffalo was host to the 30th Annual Convention of the Illuminating Engineering Society. While the majority of papers presented at this meeting dealt mainly with illuminating engineering problems several of the subjects are of interest to the glass industry in as much as they deal with the uses of various glasses and give data on subjects that are related to both fields. Brief abstracts of papers that contain items of interest to the glass field are given below. The paper by Sherwood on "Glass to Moderate Glare and Heat from Windows" is reprinted in part.

Glass to Moderate Glare and Heat from Windows. ***By L. T. Sherwood.***

If industrial buildings were to receive only the daylight admitted by relatively few small windows, as in times past, the glare and heat of sunlight could—whether to complete satisfaction or not—be controlled by shades or awnings; but to shield in this manner the huge windows of modern "daylight" factories is usually not undertaken. And yet, both solar radiant heat in summer and glare on any bright day throughout the year would often be beyond human endurance if some preventive steps were not taken. If magic could be invoked, one might ask, as pointed out by a forward-looking engineer, for a new kind of glass which, whenever not exposed to direct sunlight, would transmit 100 per cent but, whenever confronted by Old Sol, would automatically reflect outdoors all the infra-red and all but perhaps 10 to 20 per cent of the light. Magicians in glass technology of the future, please note.

In the absence of an ideal solution there have meanwhile been furnished configurated forms, such as "ribbed." or others known only by trade names, which some of the advertising extremists (not manufacturers) would, in their enthusiasm, have us accept as hardly less than magical; and the glass industry has also offered other types, which may or may not be configurated, and which are sometimes rather hastily classified simply as "heat-absorbing" but will here in general be referred to as glasses of special chemical composition. This paper is primarily concerned with the characteristics and applications of the latter glasses.

Whereas the transmissions of ordinary glass for the various wave-lengths of visible light and non-luminous heat (infrared) from the sun lie within the rather narrow range of about 75 to 92 per cent, all the kinds under discussion are in these respects more highly selective. Commercially they are of two rather different types. In one type a maximum absorption of non-luminous heat, with a minimum sacrifice of light, has been sought and such glasses may best be described as "infra-red-absorbing." Although, theoretically, such glass need not be colored at all, it is commercially identifiable as greenish blue. The other type not only selectively intercepts the solar infrared but also intentionally absorbs enough light, particularly towards the ends of the visible spectrum, to moderate glare acceptably in many applications. It may be referred to as a "double-purpose" glass and is characterized in part by a color which has been loosely called light brown or—still more loosely—amber.

The highest possible achievement of the former type, of course, would be to absorb all the infra-red but substantially none of the light. While that goal has not been fully attained, certain characteristics of this hypothetical glass are here relevant. As one feature, it would be colorless—an advantage from some points of view. It would not, however, moderate glare any more than ordinary glass. In specific instances, where glare from windows is not objectionable, where the extreme luminous intensity of sunlight might either be wanted or else could be tolerated without difficulty, and where the heat reduction resulting from absorption of the infra-red alone might be conceded to be enough, it would seem an appropriate choice.

Incidentally, without wishing to exhibit all the skeletons in the family closet by dwelling too much on things which ought to be made but which are as yet beyond the ability of glass manufacturers, selective reflection to the outdoors would of course be preferable to selective absorption which results in raising the temperature of the glass itself and a further problem of heat disposal. Since no commercial progress toward this end has yet been disclosed, courageous inventors might tackle it as a little preliminary to the aforementioned magical window.

One of the first questions which confronted the manufacturers of the double-purpose glass was to know how low a light transmission is necessary to moderate the glare incident to sunlight to an extent generally acceptable in those industries which find glare a problem, having at the same time due regard for the sacrifice on dark days, etc. Especially as mere measurement of glare has remained too elusive, even for science, there were at the outset no previously existing quantitative standards suited to this purpose; but, after more than twelve years of full-scale practical trial in widely diversified industries, it may at least be said safely that for vertical walls of industrial buildings a lower light transmission than 40 to 50 per cent is usually hardly necessary.

If glass were regarded simply as a material expressly intended to transmit a maximum per cent of light, and if the purpose of the vast continuous walls of glass in modern factories were merely to get the greatest possible quantity of light, regardless of other considerations, the figures of 40-50 per cent might seem surprisingly small. Accordingly, it may be timely before going further to inquire as to the real purpose of continuous windows. In partial reply, engineers particularly qualified to advise in this respect point out that when individual windows alternate with blank wall areas some of the workers get too much light, if the sun is on them, while others may get scarcely any. While this explanation might be much further elaborated, they advise in short that the primary reason for continuous windows and also high ones is to gain a superior *distribution* of light and not mere quantity.

When windows are continuous and high, there is evidently a surplus of illumination in sunlight, and at such

times, needless to say, occupants cordially welcome the moderated intensity resulting from a transmission of but 40 to 50 per cent. On dark days the sacrifice of light by the double-purpose glass is of course undesirable but, even if it were a serious disadvantage, the hard fact cannot be escaped that in many instances something has to be done about glare and that in the absence of a better solution the lower transmission is accordingly justifiable on that ground alone.

But how serious, as a matter of fact, is the loss of light when interpreted in terms of ability to see—a criterion which really counts? While a precise answer is of course hardly possible, Luckiesh and Moss[1] advise: "In general it is practicable and permissible to state that the intensity of illumination must be doubled in order to obtain an obvious and significant improvement in seeing." In other words, if, instead of 40 to 50 per cent, the transmission on a dull day were 80 to 90 per cent, as with ordinary window glass, there would be gained only one minimum step "upon the basis of an observable improvement in seeing." Against this minor disadvantage is to be credited the improvement in seeing due to moderation of glare under other conditions. As an instance, when mill workers are examining white paper or light-colored textiles for hours at a time while the sun is on the windows, certainly no one doubts that they can see better if the abnormally intense brightness is cut in half or is still further reduced. That is to say, moderation of such glare not only avoids personal discomfort and injury but tends to better seeing and better work. An additional consideration, too far beyond the scope of this paper to discuss at length, is that, apart from glare, the normal lessening of visual acuity may be retarded, or even prevented, if the characteristics of the glass are such that, in reducing the quantity of light, there is a selective absorption near the ends of the spectrum, particularly the blue.

As another point of practical experience, occupants themselves have never, to the author's knowledge, objected that a light transmission of 40 to 50 per cent was too low but, on the contrary, there have been actual complaints to the effect that it was too high; that is, the glass sometimes did not reduce glare as much as wanted. In specific instances the complaints were probably right although some occupants seem inclined to greater sacrifice of light than warranted in view of reports elsewhere. In this connection the requirements in tinted spectacles are sufficiently similar to suggest a reference to the studies of W. W. Coblentz. When protection is required, he suggests Shade "B" (45 per cent transmission) or "C" (30 per cent) "to meet all conditions," although indicating that still darker glasses may sometimes be preferable and that for specific purposes lighter ones may be prescribed.

As an incidental friendly reminder—highly relevant to this general subject and primarily for the notice of mill architects—if reasonable provision against glare is not made in the plans for a "daylight" building, occupants commonly take matters into their own hands and coat the windows liberally with paint. In so doing they are apt to sacrifice much more light than justifiable on dark days as well as to incur other disadvantages well known to alert managers and to maintenance engineers.

Before turning to another phase of the subject, it cannot be emphasized too strongly that the arguments for 40 to 50 per cent light transmission, or somewhat less in certain uses, are not correctly construable as a plea for low levels of illumination. Quite to the contrary, in hundreds of buildings, having the continuous windows required for best distribution and otherwise designed for natural illumination, intensities are still very high, as intended, after the transmission is cut in half. The really serious deficiencies of light in buildings in general arise from failure to "design for daylight" along lines such as those ably discussed by Higbie, Randall, Martin, and others in I. E. S. TRANSACTIONS.

If absorption of light by glass were to amount to only a very few per cent, it would not, for purposes of glazing, be regarded as colored at all. If as much, say, as 15 per cent in types under discussion, certain color effects would be apparent to many persons; and if around 40 per cent or more, the material would be universally regarded as "colored glass" and there would be no difficulty in visually demonstrating that chromatic effects may attain importance hardly less than of heat and glare. Since there may have been a tendency to think of the colors of glass somewhat as a decorator might regard a color scheme, it seems timely to mention considerations which are not merely matters of individual taste and which are at least nearer the fundamentals involved.

While there is, of course, more than one aspect, it is thought that specialists in the subject of color in lighting will agree that it is not arbitrary to say that the consideration of principal importance to mill architects is the color of light from sun and sky, after transmission through the glass, because the color of all indoor objects is contingent thereon. At any rate this approach to the subject had its origin with a well-recognized adviser. While, unless in particular instances, a minor change in the color of inanimate objects in a mill might not seriously matter, the leeway is quite limited if objectionable alteration in human complexions is to be avoided. Factory workers are probably no less responsive to such psychological influences than are other people, as instanced by the dislike of many of them for the unnatural complexions under mercury vapor lamps—at any rate the older types. Another illustration, which in some respects is more directly applicable in this discussion, is the grossly unnatural color cast upon the face of a person, in daylight, wearing celluloid eye shades of a color more or less approximating that of green grass. Although beautiful lawns are pleasing to all, and grass is spoken of as "easy on the eyes," such a color, in view of the effect mentioned, would be a strange choice for window glass.

The color resulting from the inclusion in glass of ferrous compounds, which are so useful in selectively absorbing infrared, is greenish blue and, in the case of a heat-intercepting glass from Continental Europe, said to have a light transmission of about 35 per cent, the human complexion is no less greenish and unnatural than under the celluloid eye shades. If thickness were reduced or if less of the ferrous compound had been used, so as to have a light transmission of about 70 per cent, unobserving occupants of a building glazed with such glass might not be aware of any effect upon complexion unless a person were to stand alternately in front of an open window and a closed one. It would

then be seen that the glass causes a pallor, as might result from illness. This effect naturally is more conspicuous if light is wholly from blue sky instead of mainly from the sun.

All tendency to depression in the human complexion can be avoided by glass in which color has not been completely subordinated to the selective absorption of infrared, the need for such a type being especially great if windows having low enough light transmission to moderate glare are wanted. For example, the opposite trend is found in the double-purpose glass, whose spectral transmission is given in the following table, and which merely causes a person to look a bit tanned as if just back from a healthful vacation:

Spectral Transmission of Double-Purpose Glass

Wave-Length	*Per cent*	*Wave-Length*	*Per cent*	*Wave-Length*	*Per cent*
0.334	0.0	0.783	29.6	2.018	41.0
0.365	10.2	0.883	20.1	2.277	43.1
0.405	35.4	1.003	15.9	2.557	43.6
0.436	32.2	1.139	15.4	2.644	41.8
0.546	51.3	1.284	17.6	2.726	29.3
0.579	56.0	1.428	24.0	2.806	5.1
0.607	57.4	1.568	33.5	2.838	2.3
0.638	54.8	1.701	39.6	2.883	0.0
0.702	44.3	1.804	40.3		

Judging from comments by architects and building occupants upon the cheerfulness of light from blue or clouded skies, after transmission through this glass, there would seem also to be other desirable psychological influences. While a complete explanation of such effects may better be left to psychologists, an illustration in physical terms, as provided by transmission curves is instructive to the extent of showing that, after transmission, light from blue sky is whitened and rendered more like noon sunlight in the sense that the predominance of blue has been cut down without causing undue prominence of any other hue.

The curve of spectral transmission derived from the tabulated data not only identifies the color of this particular glass (¼ inch thick) but, of course, serves also as a basis for computing transmissions of both light and heat from any source whose spectral energy distribution is known. Curves plotted to different scales for different purposes are available. For sunlight, the light transmission is about 51 per cent and the heat (total energy) transmission is about 35 per cent. Corresponding heat transmission values, resulting from tests with electric lamps, are not here quoted, since they at best tend to depart from fundamentals and have sometimes been misleading. Although, of course, sunlight, as received on earth, is variable in character, nevertheless air-conditioning engineers would be enabled to figure on severe conditions (the conditions with which they are especially concerned) if the energy characteristics of sunlight, at some appropriate angle, as transmitted by relatively dry air, were adopted as a standard for purposes of computation. It is thought that existing Smithsonian data would answer this particular purpose and that a standard could be chosen.

It is worth noting that whereas the previously mentioned hypothetical glass, which absorbs all the infrared and nothing else, transmits about 47 per cent of the solar heat, this double-purpose glass transmits but 35 per cent.

Elsewhere in technical literature there are extensive discussions, from the standpoint of air-conditioning, concerning the radiant energy transmitted indoors and also the heat which is absorbed by the glass itself, but the distinction between personal discomfort from radiant heat and from excessive air temperature seems worthy of a little more attention since it has often been found, even in some branches of the engineering profession, that the point, probably through forgetfulness, is not well understood. In a room whose air temperature is 80 degrees F a person need not be uncomfortable if situated just barely to one side of a window of ordinary glass upon which the sun is shining; but, if he takes perhaps only a single step to a position in front of the window, the heat, as everyone knows, may become distressing. Yet the air temperature is substantially only 80 degrees as before. As illuminating engineers fully understand, the difference arises from absorption by the person himself of heat radiated directly from the sun. If the window is glazed with an effective heat-intercepting glass instead of the ordinary kind, the intensity of radiation is cut down and this fact, rather than effects upon air temperature, is the immediate and essential reason for the increased comfort actually experienced. While glass, of course, is a factor affecting air temperature, results in that respect are subject to variations from many incidental causes and also to control by ventilation or artificial cooling. Incidentally, protection of workers in front of windows or under skylights from direct solar radiation, by means of glasses of special chemical composition, has for some years been found worth while whether buildings are air-conditioned or not.

It may be of interest here to recall that the very first incentive to produce a commercial heat-intercepting glass for windows was a letter twenty-one years ago from the Electric Bond & Share Co., to which was attached a typewritten copy of the original paper by Sir William Crookes which in due course proved to be the forerunner of various advances. The Electric Bond & Share Co. asked for such a glass to protect electric generators, etc., from the sun. Obviously there may also be advantages in protecting other kinds of machinery from the heat of sunlight to avoid hot bearings, undesirable expansion of some parts exposed to radiation, etc.; and, although these phases have long been neglected, an increasing future realization of such possibilities is forecast. Industry is also on the threshold of finding further applications for appropriate glasses in windows to protect foodstuffs and various manufactured products from solar heat and from undesirable photochemical changes. Incidentally, double-purpose glass is now in use in archives, libraries and museums to retard fading, etc.

The Use of Color Filters in Visual Photometry. ***By W. F. Little and R. S. Estey.***

With the exception of certain special cases color differences are common in visual photometry. In order to permit an accurate brightness match the color difference must be eliminated. This is usually accomplished by means of filters. As the selection of such filters by the trial and error method is obviously unsatisfactory the authors illustrated principles which make the selection of color matching filters easier and more accurate. This selection involves the color characteristics of individual observers as compared with an hypothetical standard observer.

All colors can be represented on a mixture diagram which is the modern equivalent of Maxwells' color triangle. By plotting the colors being photometered on such a diagram and by including the effects of such filters that are likely to be useful the best color matching filters can readily be found. Particular filters such as the various Corning signal glasses, the Jena glasses and others are fully described and then calibrations are fully shown for use in raising or lowering color temperature and for matching mercury and sodium. The types of filters for matching neon, carbon arc and other sources were suggested and the errors and difficulties peculiar to this branch of photometery were described.

Filters for Artificial Daylighting, Their Grading and Use. *By H. P. Gage and N. Macbeth.*

The emission of incandescent tungsten can be altered to the luminosity distribution of natural daylight by a filter, which by use of the Wien radiant energy distribution formula is shown to require spectral transmittances, the logarithms of which, βt, fall on a straight line when plotted against the reciprocals of the wavelengths. The locus is defined by

$$\beta t = .4343\ C_2 \left(\frac{1}{\lambda_1} - \frac{1}{\lambda}\right)\left(\frac{1}{\theta_2} - \frac{1}{\theta_2}\right)$$

where C is the second radiation constant, λ is wave length at which the log transmittance for thickness T is β^{λ}, is the wavelength for which the correction is zero, θ is the color temperature of the transmitted light. For any given glass the difference between reciprocal temperature is proportional to the glass thickness

$$\frac{1}{\theta_2} - \frac{1}{\theta_1} = At,$$

and is independent of the temperature of the source. The unit of reciprocal temperature is the micro-reciprocal degree ("mired"). The behavior of any daylight correcting glass can be defined by A, the "mireds" per unit thickness.

The Macbeth Whiterlite glass is a type of blue glass, obtained by using a well-known coloring agent dissolved in an unusual glass composition. While there is an excess of red and near infra-red transmitted, this band has been moved out far enough toward the insensitive part of the retinal response curve so that it is not troublesome in most cases. As a compensation the characteristic cobalt humps in the middle of the spectrum have been greatly smoothed out. The glass has a low coefficient of thermal expansion and is more heat resistant than any other type of blue glass. This combination of heat resistance with smooth spectral transmission renders it the best glass developed for partial correction. Its heat resisting qualities permit the use of 1500-2000 watt lamps without breakage and without cutting in quarters and binding.

The practical use of such filters were described, together with illustrations of commercial applications and lamps and reflector equipment.

The Amount of Luminous and of Ultra-Violet Solar Radiation Received on Certain Vertical Planes. *By W. Kunerth, R. D. Miller and H. T. Hurley.*

Using the data previously determined on a horizontal plane the authors calculated what the result would be on vertical planes facing east, west, south and north. This was done for both the visible and for the antirachitic part of the spectrum. The effect of cloudiness was also determined.

The data was presented in the form of tables which show, in the case of the luminous flux, the lumen-hours per square foot, month by month from the sun, the clear sky and the gray sky for the various vertical planes. In the case of the ultra-violet region, similar data was presented but the unit of measurement used was the uranium cell unit-hours.

By the use of these tables it is possible to determine the flux entering a window if corrections for reflection and absorption of the window pane are made. This correction would vary with the radiation considered and with the characteristics of the glass. In their conclusions the authors showed that luminous radiation penetrates the atmosphere much better than does the antirachitic radiation by the fact that 62.5 per cent of the radiation in the visible from a clear sky comes from the south half, whereas, only 55 per cent of the total ultra-violet radiation comes from the south half of the sky. This was to be expected for the shorter wavelengths are scattered much more than the long ones from the visible part of the spectrum, More of the shorter wave-lengths than of the longer are also absorbed by the atmosphere. This was shown by the fact that, on a south exposure for the sun alone, the luminous radiation is maximum for March and October when the altitude of the sun is low, whereas, for the ultra-violet that maximum comes in May, and July and August. The fact that the May maximum is not so well marked can be accounted for by the great amount of cloudy weather at that time. Since the maximum for the ultra-violet comes at a time when the altitude of the sun is much higher than when the maximum for the luminous appears, it goes to show that the greater absorption by the greater layer of atmosphere which the radiations have to penetrate when the sun is low are responsible for the difference.

The reason why solar radiations are much more abundant at some times of the year than at others, is not only because of the variation in the solar constant or the solar distance, nor because of the variation in the sun's altitude, but also because the days may be longer or the orientation more favorable, or there may be less cloudy weather.

These data were determined for 42 degrees N. latitude and there would be a variation as latitude changes. A change in longitude might, however, make just as much difference because of the variation in cloudiness.

Reference to the tables which were presented also reveal the fact that the fraction of ultraviolet coming to north windows directly from the sun is very small as compared with the fraction of the visible coming into the same opening. This is due to the fact that the sun shines into north windows only early in the morning and late in the afternoon when the light has to come through a deep air layer, where the ultraviolet is more abundantly absorbed. It should also be noted here that no useful ultraviolet penetrates ordinary window glass.

For each orientation for the visible, the clear sky yields more than the gray sky in summer and less than the gray sky in winter. This is due to the greater amount of cloudiness in winter. For the ultraviolet, the same

would be true but for the greater absorption of the ultraviolet by clouds. Both clear sky and gray sky yield more in summer than in winter both from visible and from ultraviolet, because of the longer days in summer.

Polarized Light for Motor Vehicle Lighting. ***By L. W. Chubb.***

A selective system of vehicle lighting using polarized light and giving ample driving light with freedom from glare was described. It was also shown that differentiation between driving light and opposing headlights can be obtained by one of four methods of selection. The most preferable method, that using polarized light at 45 degrees, is fully covered. Polarized light, the various means of obtaining it, especially polarization by materials such as the periodides of quinine and cinchonidine sulphates and various systems of applying it to vehicle lighting are described.

The adaption to motor vehicles and a comparison with the current system of beam control are given. A discussion on safety, the need for legislation and the necessary steps to adopt the system was also given.

NEW CANADIAN SAFETY GLASS PLANT

A new plant for fabricating safety glass has just been completed at Windsor, Ont. for Duplate-Windsor, Ltd. The plant, designed and erected by The Austin Co. of Canada, Ltd., is situated in the heart of Canada's largest automobile manufacturing district, within view of the Chrysler factory which it is under contract to supply with safety glass.

The building itself measures 75 ft. x 190 ft. with a modernistic curved facade of buff color face brick and ornamental art stone. Window panels of glass block have been installed on either side of the entrance, which is surmounted by a massive slab of stone with horizontal grooves. A broad band of horizontal sash extends around the rest of the office area.

The plant proper is laid out with columns on 25 foot centers, and three bays from side to side. It divides into three sections. Unloading, handling and rough cutting of plate glass delivered in car load shipments is concentrated in the back, where a 2 ton crane operates across the width on a 25 foot span. Adjoining this section is a 50 ft. x 56 ft. armour plating room built of hollow tile to a height of eight feet. Inside this area are furnace pits, air compressors, hydraulic accumulators and the main switchboard. Extending forward from this department to the office area are the finishing, inspection, packing and shipping departments.

A non-combustile metal roof deck, with 1½ inch insulating board under the waterproofing, slopes toward the center to permit drainage through cast iron downspouts inside the plant. Thus it has been possible to eliminate troughs and downspouts outside the building, which achieves a streamline appearance through the use of an entirely new type of deep metal curb. The curb has been made a structural member, with a bottom angle extending outward to form a sash sill and a top angle turned in to support the roof deck. In this way a continuous smooth eave treatment has been obtained.

A monitor, extending lengthwise over the central bay in the mid-section, increases the light and ventilation. Open trussed steel joists support the roof and carry lighting conduit on their lower cords.

Due to the extreme cold encountered in this locality, sash sills, jambs and coping have been caulked with a non-setting bitumen. The plant is situated in a natural gas field and is equipped with gas fired unit heaters, thermostatically controlled electric fans, and vented through the roof.

Due to the nature of the manufacturing operations, which require large quantities of water and leave a gritty refuse of glass grindings, it was necessary to provide a complicated system for underground drainage, including a large number of clean-out sumps. Provisions for drainage facilities, annealing pits and inside downspouts, plus an unloading dock at car height and a truck loading entry below the ground level were made in the original concrete work.

PLATE GLASS PRODUCTION UP AGAIN

The total production of polished plate glass by members of the Plate Glass Manufacturers in July was 16,427,849 square feet as compared to 16,243,665 square feet produced by the same companies in the preceding month, June, and 13,908,529 square feet in July 1935.

Duplate-Windsor, Ltd., is fabricating safety glass for Canada's 1937 Chryslers in a new streamlined plant at Windsor, Ontario, designed and erected by The Austin Co. of Canada, Ltd.

HALF OF FELDSPAR PRODUCTION USED BY THE GLASS INDUSTRY

In a report on the feldspar industry, the Bureau of Mines points out that glass manufacturers took 103,499 short tons of ground feldspar in 1935, which was 51.7 per cent of the production. Pottery manufacturers were the second largest consumers and together with the glass industry consumed 84.9 per cent of all the ground feldspar produced.

The total output of crude feldspar in 1935 in the United States was 189,550 long tons valued at $1,005,021. This is an increase of 22.9 per cent in quantity and 17.8 per cent in value over the previous year. Chief producing states were: North Carolina with 82,500 long tons, a gain of 3 per cent over 1934; Colorado with 22,275 long tons, an increase of 100 per cent; and South Dakota with 22,099 long tons, a gain of 141 per cent.

The report further pointed out that total sales of ground feldspar in 1935 amounted to 200,095 short tons valued at $2,659,140. This represents an increase of 38.8 per cent in tonnage and 42.3 per cent in value as compared with 1934.

AN ERROR IN AUGUST ISSUE

As a result of a mechanical error, two of the captions in an article entitled "The Identification of Stones in Glass" by C. L. Thompson on page 265 of the August GLASS INDUSTRY were placed under the wrong figures. The caption for Fig. 16 should read "Corundum and nephelite from below glass line (x 160)." The caption for Fig. 17 should read "Similar to Fig. 15 (x 80)."

ICELAND'S FIRST GLASS FACTORY

Reykjavik is now the location of Iceland's first glass factory, according to the Department of Commerce. Three melting furnaces will be used to manufacture "white" glass and fine glass, all of which will be done under the supervision of English technicians. It is believed that for the present it will be necessary to import raw materials from abroad and that production will be temporarily limited to various types of bottles.

TREES OF GLASS

Glass trees are reported to be the latest thing in Hollywood stage settings. Robert Usher, a scenic designer, brought over quite a bit of this flexible glass from Vienna for use in his pictures. Although the material can be bent double, 140,000 pounds pressure are required to break it. To make the glass stay bent in any particular shape, steam is applied. The next time you go to California, don't be surprised if you see glass palm trees waving in the breeze!

An interesting new application of glass is to be found in helical coils of glass, possessing the properties of a spring. These coils about ¼ inch in diameter and made of glass "wire" are said to have a deflection of approximately 20 per cent of their free length. Use of these springs so far have been limited to experimental work where high resistance to corrosion was required.

MIRROR STANDARDS REVISED

Under date of July 9, 1936, a recommended commercial standard for mirrors (Revision of Plate Glass Mirrors, CS27-30) was circulated for written acceptance. Since that time the National Bureau of Standards has received signed acceptances from a number of manufacturers, distributors and users estimated to represent a satisfactory majority. Therefore, in the absence of active opposition, the commercial standard, identifiable as CS27-36, may be considered effective for new production from Aug. 20, 1936.

N. Y. CARS MUST HAVE REFLECTORS

Glass men will be interested to learn that the New York Legislature has ruled that effective Oct. 1, 1936, all motor vehicles must be equipped with Class A red reflectors in addition to tail lights. These reflectors are to be constructed of ruby red optical glass, microfocused, with a 30 to 40 degree angularity reflection and visible for at least 200 feet. Since there are 2,395,144 automobiles and trucks registered in New York state, this legislation may prove fruitful for manufacturers of optical glass.

SOLEX REDUCES AIR-CONDITIONING COST

A reduction of eight degrees in the mean temperature of a room is now possible through the use of Solex glass, a development recently announced by the Pittsburgh Glass Institute. This heat-absorbing glass differs in appearance from ordinary plate glass only in its slightly aquamarine color, which relieves the eye from the strain of too bright a glare but in no way interferes with perfect vision. The heat-absorbing qualities of Solex are due to the presence in glass of both ferric and ferrous iron which respectively absorb both ultraviolet and infra-red rays, the chief elements in solar heat that cause discomfort and deterioration.

POWER SHOW IN NOVEMBER

The Twelfth National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York City, Nov. 30 to Dec. 5. Equipment displayed will include the following classifications: fuels, combustion equipment, refractories, steam generating and distribution equipment, piping and fittings, prime movers, pumps and hydraulic equipment, as well as various electrical, control and precision, air conditioning equipment, etc.

REFRIGERATING SPECTACLES

A pair of refrigerating spectacles said to be the most efficient refrigerating unit yet devised to cool the human eye were exhibited at the annual meeting of the American Academy of Optometrists. The lenses were designed to prevent cataracts, a frequent cause of blindness. The invention was based on the theory that invisible infra-red light rays are so hot they cook the albumin of the eyeball into thick opacity. The development was announced by Dr. E. LeRoy Ryer and Dr. Elmer E. Hotaling of New York.

An analysis of the physical condition and appearance of approximately 8,000 small and medium-sized stores and service establishments in 23 selected cities of the United States has revealed that over half are in need of modernization in varying degrees, according to *Store Modernization Needs*, a study made by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

EQUIPMENT AND SUPPLIES

CATALOGS RECEIVED

Barriers to Industrial Waste. Johns-Manville, 22 East 40th St., New York City. A revised edition of a previous booklet with the same title. Profusely illustrated, it describes in detail more than 50 installations for all types of heated or refrigerated equipment. A table of recommendations suggest the proper insulations to meet a wide variety of industrial requirements.

Pyrometric Heat Control. Wheelco Instruments Co., 1112 Milwaukee Ave., Chicago. A new series of bulletins presenting an interesting and informative detailed analysis of the recently developed "Radio Principle" type of pyrometric control instruments.

Common Sense Ventilation. Bulletin V-100-B. Swartwout Co., 18511 Euclid Ave., Cleveland. A non-technical bulletin on the more or less technical subject of ventilation for industrial and commercial buildings. Fully illustrated with photographs and diagrams, this publication explains in a most understandable manner the Swartwout method of natural ventilation.

The Story of Manganese Steel. American Manganese Steel Co., Chicago Heights, Ill. Glass men will be interested in reading this attractively conceived folder which tells briefly and graphically the many ramifications of the "toughest of known steels."

Wheelabrator Multi-Rotary Table. Folder No. 33. American Foundry Equipment Co., Mishawaka, Ind. Gives information about the money-saving possibilities said to be obtainable through the use of the Wheelabrator for cleaning castings or de-scaling forgings.

WHEELCO APPOINTS TWO

Wheelco Instruments Co., Chicago, has announced the appointment of Elmer A. Schneider as production manager. Mr. Schneider was formerly owner of the Mishawaka Pyrometer Co., and previously had been with Leeds and Northrup, Brown Instrument Co. and the Republic Flow Meter Co. George W. Keller, formerly vice-president of Brown Instrument Co. is now in charge of the eastern sales division of Wheelco.

INTRODUCES SHADOWGRAPH SCALE

The Exact Weight Scale Co., Columbus, Ohio, manufacturers of measuring equipment for color control, batch mixing and check weighing for uniformity, have introduced the Shadowgraph which embodies a new principle in precision weighing. The shadow feature eliminates all indicating mechanism entirely and thereby a parallax is completely overcome. The company claims the following advantages for the Shadowgraph: long travel for delicate weights, increased speed in high speed production, weighs out of level, rubber mountings to eliminate noise and cut depreciation, provides its own illumination, completely self-contained, easily accessible dashpot, soft finish to eliminate eyestrain and portable for easy moving.

AUTOMATIC LUBRICATOR

Production men in glass factories who have been lubricating the molds on glass machines by a constant oil drip will be interested in a new device that is effecting definite economies.

An air line is piped to each machine. Into the air line is introduced an automatic lubricator, consisting of a device for feeding a single drop of oil into the air stream at regular intervals and a trigger for tripping the air valve every time a mold arrives under the jet.

As each empty mold reaches a position under the jet, the trigger is tripped, a single drop of oil is finely atomized in the air stream and the mold is filled with the fog of oil. One mold then moves on to the torch, which carbonizes the oil coating inside the mold and thus provides perfect lubrication for withdrawal of the finished glass unit. No oil is sprayed on the outside of the mold nor on the machine; not a drop of oil is wasted. The device is said to pay for itself quickly in oil saved and to have the added advantages of reducing fire hazards, and keeping the glass machine cleaner.

The lubricator is widely used in a number of industries for applying lubrication in fog form to a wide variety of mechanisms. Its application to glass manufacture, however, is new. A special large-capacity reservoir has been provided. A conventional boiler-type glass gauge on the side of the reservoir always indicates the supply of oil. A sight feed gauge at the top indicates how much oil is introduced to the air stream at each interval. Both gauge tubes are of pyrex glass, all gaskets are of asbestos material, so the entire equipment withstands the heat attending any glass molding operation. C. A. Norgren Co., Inc., Denver, Colorado, manufacturers of the equipment, assert that installation is simple and can be executed by any intelligent mechanic. A lateral from the plant air line is brought to each machine and connected to the lubricator. The jet pipe adjusted as to position completes the installation.

NEW 9-INCH LATHE

The South Bend Lathe Works, South Bend, Ind., announces that the new 1936 model 9-inch workshop lathe may now may be had with the new pedestal type of motor drive. The pedestal motor drive mechanism is a separate unit mounted on a metal pedestal back of the lathe, with the horizontal countershaft and motor supported at the top of the pedestal in line with the headstock cone pulley.

An adjustable tension trace between the countershaft and the headstock regulates the tension of both the flat belt between the cone pulleys and the V-belt from motor to drive pulley. A belt tension release lever attached to the tension brace permits easy shifting of the cone pulley belt from one step of the pulley to another. When the lever is pulled towards the operator, the motor drive is tilted forward on its pivoting frame sufficiently to easily shift the spindle belt.

Readers may obtain further information about this lathe from the Technical Service Department, South Bend Lathe Works, South Bend, Ind.

Announcement is made by the Harnischfeger Corporation, Milwaukee, of the appointment of the Arthur Wagner Co., 701 West Washington St., Chicago, as agent for Northern Illinois.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks ...Per 100 lb.		.	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.15
52% and 48%	lb.	.10	.12½-.11½
Nitric (HNO_3) 130 lb. carboy ext. Per 100 lb.		...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Aluminum hydrate (Al (OH)3)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14½
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	.12	.12
Antimony oxide (Sb_2O_3)	lb.	...	.12¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	**40.00**	**45.00**
90% through 100 mesh	ton	38.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.0475	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
(Commercial, 25% Selenium)	lb.	...	.90
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated ...In bags,	lb.	.022	.0245-.027
Powdered ...In bags,	lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated ...In bags,	lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	.90-.95
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	**.0215**
Cerium hydrate			
100 lb. drums and 600 lb. barrels	lb.	...	**.65**
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3)			
In bbls.	lb	...	1.41
In 10 lb. tins	lb.	...	1.51
Copper oxide			
Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	**.22**
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	**.07**
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	**8.00-9.00**	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	**.16**
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0710	...
In 5 Ton lots	lb.	...	**.075**
Less than 5 Tons	lb.	...	**.08**
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls. ...Per bbl.		**2.25**	**2.25**
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.0610	...
In 5 Ton lots	lb.		.065
Less than 5 Tons	lb.		.07
Magnesium carbonate ($MgCO_3$)	lb.	.0610	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0275
Manganese, Black Oxide			
In Paper bags	ton	47.50	52.50-55.00
In Burlap bags	ton	51.50	54.00-56.50
In Casks	ton	53.00	55.50-58.00
Neodymidm oxalate, 50 lb. drums	lb.	...	**5.00**
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	**31.00**	**23.00-29.00**
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate			
Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅜
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.27
Potassium hydrate (KOH) (caustic potash)	lb.	**.06¼-.06½**	**.08-.08½**
Potassium nitrate (KNO_3) (gran.)	lb.	.0545	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.18¾-.19¼
Rare earth hydrate			
100 lb. drums	lb.	...	**.35**
325 lb. barrels	lb.	...	**.30**
Rochelle salts, bbls.	lb.	...	**.12½**
Rouge	lb.	...	Po. or Gr. .13½ / Cry.
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%—			
Bulk ...Flat Per 100 lb.		1.10	...
In barrels ...Per 100 lb.		1.50	...
In bags ...Per 100 lb.		1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08¾
Sodium fluosilicate (Na_2SiF_6)	lb.	.07	.07½
Sodium hydrate ($NaOH$) (caustic soda)			
Flake ...Per 100 lb.		3.00	...
Solid ...Per 100 lb.		2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls. ...Per 100 lb.		...	**2.00-2.25**
95% and 97%			
Bulk ... Per 100 lb.		1.225	...
200 lb bags		1.29	1.34
100 lb. bags		1.325	1.375
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	**1.50-1.55**
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls. ...Per 100 lb.		3.35	3.70-4.10
Flowers, in bags ...Per 100 lb.		3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls. ..Per 100 lb.		2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.33½
Tin oxide (SnO_2) in bbls.	lb.	...	.47
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.25
Yellow orange	lb.	...	**1.50**
Zinc oxide (ZnO)			
American process, Bags	lb.	.05	.05¼
White Seal, 150 lb. bbls.	lb.	.06¾	.07
Green Seal bags	lb.	.06	.06¼
Domestic White Seal bags	lb.	.06½	.06¾
Red Seal, bags	lb.	.05½	.05¾
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.05

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Yes everything, since any glass object which cannot be properly tempered in any other make or type of lehr, can be *successfully* annealed in the NEW SIMPLEX LEHR.

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